



A systematic approach to service oriented product development

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A systematic approach to service oriented product development

PhD thesis
Dettef Matzen
2009

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Detlef Matzen

2009

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Abstract

Throughout the last years, manufacturing industry has experienced a trend towards a higher level of operational integration with their customers, i.e. manufacturers differentiate their offer from competitors by combining physical and software products with service plans and service support operations. This integration of manufacturing and service business holds a number of potential advantages, such as optimised operational performance and improved insights into use phase processes.

To realise these potential advantages, products and service operations must fit to and support each other, which calls for an integrated approach to their development. The integrated development of solution concepts spanning products, service delivery systems and matching delivery business models is the theme of this thesis. A design based approach - *service oriented product development* - is proposed for the creation of these *Product/Service-Systems* (PSS).

The contribution builds on the foundations of engineering design and product development research performed at the Section of Engineering Design and Product Development at The Technical University of Denmark, also dubbed the *Copenhagen school*.

Service oriented product development is based on the analysis of existing product life-, business- and use processes. This helps to identify the opportunities of creating improved solutions, through the combined delivery of products and services, potentially supported by altered customer relationship models.

The research contribution is based on three industrial case studies, each emphasising several aspects of the case companies' experiences and challenges in the transition from manufacturing- to service orientation. Two of the case companies are suppliers of equipment to the shipbuilding industry, the other is a global supplier of refrigeration technology.

The main contributions documented in this thesis are the following:

1. A systematic approach allowing the visualisation of product life and related use activities is defined.
2. Service oriented product development must consider a broad range of actors not directly associated with use processes, but rather linked to the product life through associated processes and crossing life cycles.
3. Synthesis of PSS concepts relies on the iterative detailing and concretisation of elements utilising three view domains, being artefact-, activity- and actor based.
4. The development of PSS concepts is a collaborative high level effort, spanning across all or many functional areas of the company.
5. The manufacturing company needs to create an organisation or team in every affected functional area in order to contribute to, receive and implement concepts from the collaborative service oriented product development activity.

Resumé

I gennem den seneste tid har fremstillingsvirksomheder i stigende grad oplevet en trend mod en højere grad af operationel integration med deres kunder og brugere. I praksis har virksomhederne i stigende grad differentieret sig fra konkurrenterne ved at kombinere deres udbud af soft- og hardwareprodukter med serviceaftaler og understøttende tjenesteydelser. Denne sammenkobling af fremstillings- og serviceaktiviteter indeholder et antal potentielle fordele, som f.eks. højere produkttydelser og forbedret indsigt i produktets egenskaber i brugsfasen.

For at realisere disse potentielle fordele, skal produkter og serviceaktiviteter være nøje afstemt og understøtte hinanden, hvilket gør en integreret tilgang til deres udvikling fordelagtig. Den integrerede udvikling af løsningskoncepter, der spænder over produkter, serviceleverancesystemer og tilpassede forretningsmodeller, er hovedemnet for denne afhandling. Disse *produkt/service-systemers* udvikling søges understøttet ved hjælp af en designbaseret tilgang – *service orienteret produktudvikling* – der præsenteres i afhandlingen. Afhandlingen bygger på forskningen i konstruktionsteknik og produktudvikling ved Sektionen for konstruktion og produktudvikling på Danmarks Tekniske Universitet, en forskningstilgang, der til tider bliver betegnet som *Københavnerskolen*.

Service orienteret produktudvikling baseres på en analyse af nuværende produktlivs-, forretnings- og brugsprocesser og bidrager til at identificere muligheder for at skabe forbedrede løsninger ved en kombineret leverance af produkter og tjenesteydelser, evt. understøttet af tilpassede forretningsmodeller overfor kunden.

Forskningsbidraget er baseret på analysen af tre case studier, der hver især fremhæver nogle aspekter af casevirksomhedernes erfaringer og udfordringer i forbindelse med den strategiske overgang fra produkt- til serviceorientering. To af virksomhederne er leverandører til skibsbygningsindustrien, mens den tredje er en global leverandør af køleteknologi.

Forskningsprojektets hovedbidrag er følgende:

1. En systematisk tilgang og visualisering af produktlivet og de relaterede brugsaktiviteter.
2. Service orienteret produktudvikling må tilgodese en bred vifte af aktører, der ikke er direkte involverede i brugsprocessen, men kun forbundet med produktlivet igennem associerede processer og krydsende livsforløb.
3. Syntesen af PSS koncepter kan baseres på en iterativ detaljering og konkretisering af elementer ved udnyttelsen af tre modelleringsdomæner, nemlig artefakt-, aktivites- og aktørdomænerne.
4. Udviklingen af PSS koncepter er en samarbejdsopgave på højt abstraktionsniveau i virksomheden, der spænder over de fleste funktionsområder.
5. Virksomheden har brug for at oprette en modtagerorganisation i de enkelte funktionelle enheder, for at kunne omsætte de udviklingskoncepter, der skabes i den service orienterede produktudviklingsaktivitet.

Preface

This thesis is also the result of four years of research and learning, a process that allowed me to meet a lot of interesting and likable people from around the world. Without their help and support, I would not have been able to get to this point, and I owe them my deepest gratitude. I would like to take this opportunity to thank some of them.

First I would like to thank my supervisor Tim McAloone, for preparing the ship, pulling me on board and supporting me on the journey. He granted me total freedom, while believing in me and offering support and free time in the difficult phases of the project.

Adrian Tan was a great partner in research, always being two steps in front or one step behind me in his own PhD project and always ready to discuss what we had seen, done or written.

Mogens Myrup Andreassen took his task of not being my supervisor very seriously, offered new views, guidance in understanding the past and asked the right questions mostly at the right time.

My friends and colleagues at K&P and IPU made the university a great place to work, learn, talk, laugh and eat lunch – and especially the latter sometimes requires effort and good humour.

The members of the PSS research network put up a mirror that allowed me to identify how I could contribute and showed the many other views on PSS development. You also added a global perspective to my limited experience.

The partners in the case companies shared their experiences and allowed me insights into their companies, work and challenges. They are the ones that link this thesis to the real world, and hopefully helped turning it into a relevant contribution too.

My family kept me from believing that research is the only thing that matters, thank you for your love and patience.



Aabenraa, May 2009

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Glossary of terms

AMC	Activity modelling cycle
AME	Americas (market region of Danfoss RA)
APA	Asia and Pacific (market region Danfoss RA)
BD	Business development (section of Danfoss DE)
CAC	Customer activity cycle
CAD	Computer aided design
CC	Customer chain
CK	Concept-knowledge theory
CVCA	Customer value chain analysis
DE	Electronic Controls and Sensors (business unit Danfoss RA)
DfX	Design for X
DRM	Design research methodology
DTU	Technical University of Denmark
E	Energy
EES	Eco efficient services
EMA	Europe, Middle East and Africa (market region of Danfoss RA)
Env	Environment
FF	Fire fighting (technology and/or division of Novenco)
FR RA)	Food retail (market segment and/or business unit of Danfoss RA)
FS	Functional sales
GST	General systems theory
HACCP	Hazard analysis and critical control points
HiCS	Highly customerised solutions
Hu(S)	Human operator (system)
HVAC	Heating, ventilation and air conditioning (technology)
I	Information
IMO	International maritime organisation
IPD	Integrated product development
IS	Information system
M	Material
M&GS	Management and goal systems
NSD	New service development
Od	Operand
OEM	Original equipment manufacturer
PD	Product development (section of Danfoss DE)
PLM	Product lifecycle management
POS	Point of sale
PS	Product service

PSC	Port state control
PTrS	Parallel transformation system model
RA	Refrigeration and air conditioning (division of Danfoss)
RD	Research and development (section of Danfoss DE)
RQP	Right quality product
RSP	Receiver state parameter
S&P	Service and Parts (department of Novenco)
SOLAS	Safety of life at sea (international convention)
SOP	Service oriented partnership
SP	Service provider
SR	Service receiver
SSM	Soft systems methodology
STS	Science and technology studies
SWOT	Strenght, weaknesses, opportunities and threats
TCO	Total cost of ownership
Tg	Technology
TrP	Transformational process
TrS	Transformation system model
TS	Technical system
TTS	Theory of technical systems
VOC	Voice of the customer

1 Introduction

The ever increasing integration of the global economy and adaptation of information and communication technologies is changing the way companies conduct business. For most manufacturing companies the cost, timely delivery and technical quality of products have traditionally been the main factors of competitive advantage. Today, the delivery of services supporting the manufactured products and the continuous availability of these support services throughout the life time of products is moving to centre stage.

The development of integrated solution concepts spanning products, service delivery systems and the reassessment of the relationship between customer and the supplier company is the theme of this dissertation. A design based approach – *service oriented product development* – is proposed for the creation of these *Product/Service-System* (PSS) concepts.

The concept of PSS is related with other terms in research literature, such as *functional (total care) products* [Alonso-Rasgado et al. 2004], *service engineering* [Tomiyama 2001] and *industrial solutions* [Foote et al. 2001]. The main reason for the growing interest in PSS these years may be the emerging recognition by many traditional manufacturing companies that they beneficially could move from product orientation to a more service based orientation, combining product and service delivery. Seen in this light PSS is the research metaphor for a business approach, which has been known and utilised by several types of companies for many decades: suppliers of aeroplane engines, large software installations, transport and logistics systems, etc. Although utilised for decades, only recently research has started to investigate the coupling between PSS business models and the tasks and role of product development in their creation. While more common in business to business relationships, also consumer oriented companies especially in the media and software business embrace the possibilities of creating service oriented business relationships with their customers.

An argument often used in favour of development of PSS is the ability to achieve environmentally sustainable business activities, as the objective is to create the highest possible use value of products for the longest possible time while consuming as few material resources and energy as possible [Mont 2004]. However, the incentive of lowering overall resource consumption is closely linked to the responsibility and revenue models governing the relationship between customer and PSS provider [Hockerts 2008], and many service oriented businesses exist where the environmental sustainability improvements are none, negative or at least not accounted for.

An example of a PSS that potentially is reducing environmental impact is the RETAIL-CARE™ service system of the Danish refrigeration components supplier Danfoss, which is a case story of this thesis. Targeting key account customers in the food retail business, Danfoss offers a combination of monitoring and engineering services supporting the refrigeration system operation of their clients' stores. Through the continuous monitoring and tuning of the refrigeration systems performance, RETAIL-CARE™ promises their customers substantially higher energy efficiency of their stores. While the service system is primarily aiming for the reduction of

Creating strategic and long lasting customer relationships

operational cost for their customers, a reduced energy consumption is a welcome environmental side effect.

The Danfoss example also lends itself for the illustration of another driver towards integrated product and service supply. Although aware of the importance of well maintained refrigeration systems, most food retail enterprises readily outsource technical management to competent sub suppliers in order to focus the enterprise competences on their core business. With a comprehensive programme of services, suppliers like Danfoss can become strategic partners of their customers, thereby gaining better insight in the operational properties of their own products and securing a stable source of income from both product and service sales.

Redefining the core business of manufacturers

Also the continuing globalisation of business and its ever increasing division of labour and competence between organisations, companies, countries and regions is a strong driver for the integration of products and services to PSS solutions. A general description of these trends related to business change and the positive and negative implications of this development is described in popular terms by e.g. Rifkin [2000]. For many manufacturing companies the globalisation of both supply and sales markets means that their products face fierce competition and former virtues of technical quality are eroded by competitors' products delivering similar functionality at substantially lower prices. One of the strategies to fight this commoditisation of products is to utilise the knowledge embedded in the company to support customers operations and thereby delivering added value compared to competitors in the globalised market. In extreme cases it may even lead to a gradual complete shift from manufacturing to knowledge and service activities.

The company MAN Diesel is an example of this. MAN Diesel, the leading manufacturer of large bore two-stroke diesel engines for marine applications effectively suspended manufacture of these engines in the 1980'ies and since then has relied on technology development, design and maintenance services, while virtually all physical manufacturing of large two-stroke engines was outsourced to licensees on a global scale. The company refocused their activities completely from manufacturing to engineering and life cycle support.

Existing service and product development focus

While many companies are engaged in PSS type businesses, few employ an integrated approach to developing their integrated solutions. Traditionally manufacturing companies employ a structured approach to the development of their programme of physical products in order to secure quality levels and requirement fulfilment. Researchers have tried to support designers, technicians and managers of product development departments in the task of developing new or improved products, being (industrially manufactured) physical artefacts. Evidence of this can be found in many books on design and development, from theoretical works as e.g. by Hubka and Eder [1996] to applied approaches presented by Ulrich and Eppinger [2000].

Regarding the development of services, the research domain of service marketing has proposed modelling schemes for services, such as Shostacks service blueprinting [Shostack 1982] in order to be able to stabilise service concepts similarly to the documentation of product concepts. Here the establishment of consistent delivery quality and the exploration of the de-

tailed processes in the interaction between customer and supplier are in focus.

In parallel to product development models, *new service development (NSD)* models have been developed such as by Edvardsson and Olsson [1996]. In general the NSD research attempts the adaption of structured development process models (such as [Ulrich and Eppinger 2000]) to the requirements of having a *service process* as object of design.

For the development of PSS, more recent research has attempted at bringing together the different approaches in so-called PSS development models [Tukker and Tischner 2006], which focus mainly on sustainability oriented service systems and associated business models.

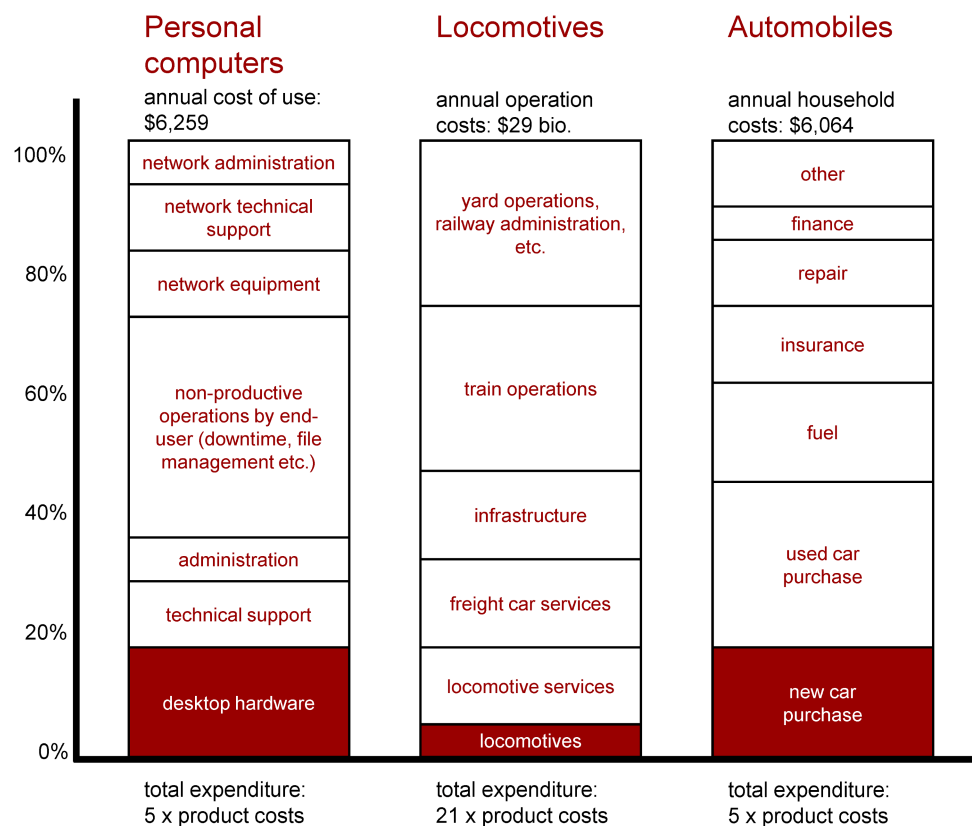


Figure 1: The initial investments fraction of the total life cycle cost of different product categories. Redrawn from [Wise and Baumgartner 1999].

In the business management literature, several contributions have been made regarding the business opportunities of either delivering services supporting the design, installation and configuration of technical systems [Davies et al. 2007] or securing part of the so-called after-sale business related to sold products [Wise and Baumgartner 1999]. Figure 1 illustrates the large fraction of the total cost of ownership (TCO) that after-sales activities amount to for selected technology products.

Foundational mindset of this work

The work of this research contribution builds on the foundations of engineering design research and research into product development as performed at the *Section of Engineering Design and Product Development* and its predecessors at *The Technical University of Denmark*, sometimes dubbed the

Copenhagen school of engineering design [Andreasen and McAlloone 2008]. The theoretical background is the modelling of products and product design, based on the domain theory of Andreasen [1980] combined with the understanding of product life implications and dispositional mechanisms as described by Olesen [1992] and the modelling of the product development activity as published by Andreasen and Hein [1987]. The understanding of service and the activities of service delivery is inspired by the conceptual service model of Tomiyama [2001]. The differentiation, or rather the possibility of categorising a company's entities along conceptually orthogonal views is based on the work of Ropohl [1999] and was further inspired by e.g. Callon et al. [2002]. The research of e.g. Latour [1991] was defining for the understanding of the cross influences between actors, processes and artefacts and the ability of artefacts to actively alter the practices of human actors. The use of abstractions and representation to allow generalisations and decision making also was inspired by Latour [1999] and the work of Cooper [1992].

Applied views in this contribution

Service oriented product development is based on the thorough analysis of existing product life and business processes and helps to identify the opportunities of creating radically improved solutions through the combined delivery of products and services in changed customer relationships. It employs a combination of several development views. One emerges from the tradition of eco-design, where the consideration of dispositional effects across the product's life cycle and interactions with other products, systems and actors is a central element. The other is the view of actor network theory and the identification of the networks of actors that are being mobilised in relation to the use activities of products.

1.1 Aim and purpose of the research project

Although most companies acknowledge that their business is in a transition phase from product and manufacturing orientation towards a service delivery orientation, the organisational structures, mindset and activity patterns of development have not yet converted to a new and adapted state. The development and implementation of the service delivery related activities is in many cases carried out on an ad-hoc and uncoordinated basis, leaving synergy potentials between the different modes of delivery neither identified nor realised.

In the past, the introduction of structured, design based approaches to product development has proven to improve development efficiency in terms of development throughput while yielding products that repeatable and precisely meet the demands of customers and markets.

With the introduction of service oriented business, it is believed that similar improvements in terms of development efficiency and precision are possible, given that product development processes can be adapted to a broader object of design, i.e. PSS solutions and business models, applying the view-points described above.

It is the purpose of this thesis to contribute to the understanding of this altered object of design and the process of developing PSS solutions.

Firstly, this research aims for the creation of a framework of models that can describe the service oriented company's offer elements in a PSS perspective. With these models a language for the creation and discussion of

PSS concepts is created as a first step towards a *service oriented product development* approach.

Secondly, the thesis will aim for insights into the relations between the development of PSS solutions and the other development tasks of the manufacturing company. The role of service oriented product development is most certainly different from the role of existing product development tasks, necessitating a reassessment of the company development systems.

1.2 Structure of this thesis

The thesis documenting the scientific outcome of the PhD project is structured in the following way.

Table 1: Structure of this thesis.

Chapter	Content
1	<i>The problem field is introduced and the general purpose of the research project is stated.</i>
2	<i>The theoretic foundations are explored through a literature review and the theoretical framework for the research project is described.</i>
3	
4	<i>Based on the theoretical insights and the chosen research framework, the research questions framing the empirical study are defined. The research strategy and the research methods applied in the empirical studies are presented.</i>
5	
6	<i>The empirical studies conducted throughout the research project are documented. The three case studies are presented in a self contained comprehensive format to allow them to be reused and explored for other purposes.</i>
7	
8	
9	<i>The insights gathered throughout the research project are presented, covering the analytical modelling of business processes, first insights regarding the synthesis process and the relations between service oriented product development and other development tasks in the company.</i>
10	
11	
12	<i>The findings of the research project are discussed and general conclusions are drawn. Finally perspectives for future research are given.</i>

2 Research background

This thesis is based on a broad range of research fields and approaches, which is illustrated in Figure 2. The general field of Product/service-system research grew out of a history of sustainability research approaches. This movement as since met by researchers exploring the business opportunities of combining product and service offers. Finally the design research community has begun to consider how to support an integrated approach to developing PSS.

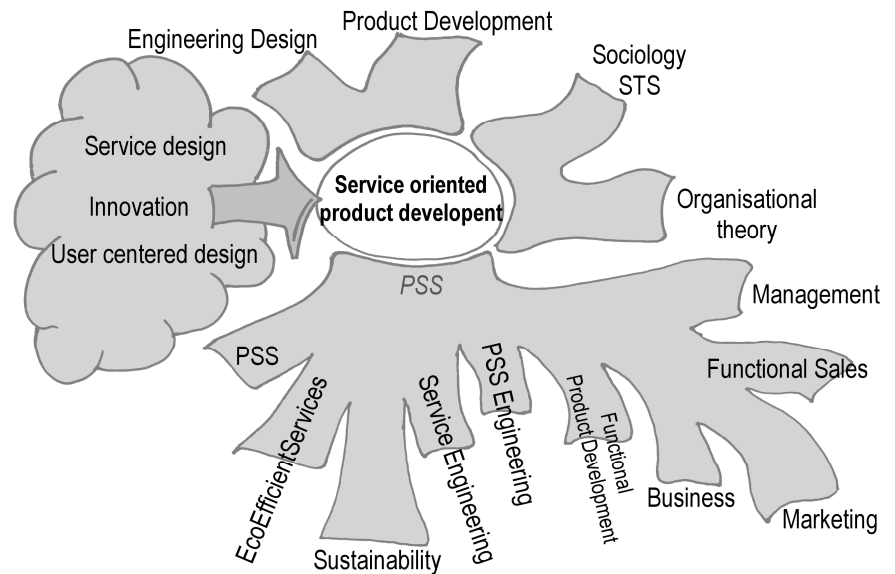


Figure 2: Multiple research areas influencing this thesis.

2.1 Origins of Product/Service-Systems research

While there exist a plethora of industrial sectors and use areas relying on the delivery of combined products and services, research only recently started investigating in the area that currently seems to be consolidating in terms of terminology to be called Product/Service-Systems research. The term and concept of Product/Service-Systems is initially rooted in environmental and macro economy research of the late 70's, which was sparked and supported by a societal growing concern for the global environment and underlined by the *United Nations Conference on the Human Environment* which was held in Stockholm in 1972. On the conference the UN assembly amongst others agreed on the creation of the *United Nations Environment Programme* (UNEP) [UN 1973] and thereby initiated the continuous UN efforts for environmental improvements.

Challenging the logic of industrial development

In 1976, Stahel and Reday presented a report entitled *Jobs for tomorrow – The potential for substituting manpower for energy* to the European Commission, which was later republished in book format [Stahel and Reday-Mulvey 1981]. In the book the authors presented the opportunity of solving the political tasks of unemployment and excessive consumption of resources simultaneously, by substituting the resource intensive *industrial economy* with a more labour intensive *service economy*:

A new industrial strategy could consist of a slow shifting of production activities [...] from manufacturing to a corresponding service sector, concentrating on e.g. long-term leasing, maintenance, and reconditioning activities.

[Stahel and Reday-Mulvey 1981]

While Stahel and Reday-Mulvey argued that this shift in industrial strategy would lower energy and material consumption and thereby decouple economic growth from environmental impact (a strategy called *dematerialisation*), the aim of the report and book was to point towards alternative approaches for improving economic growth rates, while reducing unemployment in the European Economic Community. The report must also be seen in its historical context of the period between the first and second oil crises, focusing societal and political discourse on considerations of reducing strategic dependency on foreign energy supplies.

Dematerialisation is a strategic approach to lowering the overall resource consumption of humanity. Hinterberger et al. [1994] define *dematerialisation* as a strategy for reducing resource consumption utilising two means:

One is the reduction of the material input necessary for the yield of a certain output (service unit) by ensuring the most efficient utilisation of the material products used. This covers both use efficiency in terms of e.g. energy consumption of products and the optimised exploitation of the product material itself in terms of e.g. use frequency in relation to life expectancy.

The other means is the reduction of the number of service units consumed, i.e. a paradigmatic shift towards a sufficiency society, where the lowest possible resource consumption is strived for. Options of reducing the number of service units consumed include the change of usage patterns of customers, e.g. moving traffic from passenger vehicles to public transport, thereby reducing the overall amount of traffic work performed.

Tomiyama [2001] aims to achieve dematerialisation by actively designing use systems to ensure optimised exploitation of products and reduction of the service units consumed. The means for achieving the intensification of service contents in product life cycles is the approach of *service engineering*.

This first report inspired to investigate the possibilities of reducing global resource consumption through a general societal move from an industrial to a service economy (which is also called functional economy), driven by the ideal of dematerialising economic activity and thus enabling growth without increased environmental impact.

Stating the necessity of global sustainable development

In 1983, based on the evolving work of UNEP and the continuous concern for environment and global development, the general assembly of the UN convened the World Commission on Environment and Development (WCED) [UN 1983]. The commission was to propose long term strategies for a sustainable development, while supporting a greater cooperation between developing and industrial countries.

In 1987 the WCED presented their report entitled *Our common future* [Brundtland 1987], which underlined the necessity of reducing the global environmental impacts of humankind. The report supported the reiteration of a general concern for environmental issues, and was thereby also in-

strumental in the preparation of the United Nations Conference on Environment and Development (UNCED) that was held in 1992 in Rio de Janeiro. In the report, the now generally accepted definition of sustainable development was presented, which in general terms states that

“... a sustainable development can be defined as a development that satisfies the needs of today without compromising the ability of future generations to meet their needs.

[Brundtland 1987]

Three necessary sustainability dimensions were identified, being environmental, social and economical sustainability. In many later publications these three sustainability dimensions have been discussed using the concept of *triple bottom line* sustainability performance or the slogan of *People, Planet & Profit* [Elkington 1997].

The ideal of dematerialisation seemed perfectly aligned with these dimensions as it promised the possibility of combining economic growth with reduced environmental impact, while creating good opportunities of socially sustainable labour forms for virtually everybody. Later contributions have since shown how much of the environmental benefits of dematerialisation strategies can be eliminated by various *rebound effects* [Manzini 2002].

Introducing the idea of a sustainable service economy

Stahel followed up with contributions towards the concretisation of dematerialisation strategies in later books and articles describing a future service economy and its impacts on societal structures and industrial actors [Stahel 1997]. The viewpoint was always societal sustainability oriented and concrete advice was offered regarding the adjustment of public administrative and economic mechanisms, such as tax systems and industrial policy. For enterprises and customer actors in the society, he identified possible approaches to the reduction of resource consumption through changed business and design strategies, which are shown in Table 2.

Table 2: Four business approaches to reduce society's resource consumption according to [Stahel 1997].

Approaches towards a sustainable service economy	
1	<i>Sufficiency solutions</i> , which are to avoid the emergence of resource intensive needs in the first place, by preventive action or redistribution of responsibility and liabilities.
2	<i>System solutions</i> ; were a reduction of volume and speed of resource flow are attempted through a synergy creating integration of related activities.
3	<i>More intensive use of material goods</i> , in which the single asset is utilised more efficiently through multifunctional or shared use, thereby reducing the volume of material resource consumption.
4	<i>Longer use of material goods</i> , in which the product's lifetime is prolonged through upgrading (of various characters) and the elements, components and materials are reused through closed material loops in society.

Barriers to the shift towards the service economy

Stahel also identified important barriers to the event of the envisioned service economy. Fundamentally, the current industrial economy has developed and controlled societal discourse over the past 200 years since the emergence of the industrial age, aligning societal, industrial, economic and managerial structures to be measuring success by the volume of material throughput (sales) instead of the overall creation of use value. The indus-

trial economy logic is focused on the microeconomic actors' short term optimisation (in competition with each other), instead of a long term societal optimum of natural resource stewardship. Economic actors are thus focusing on the apparent exchange value of artefacts at the point of sale (*POS* in Figure 3) instead of the utilisation activity's value.

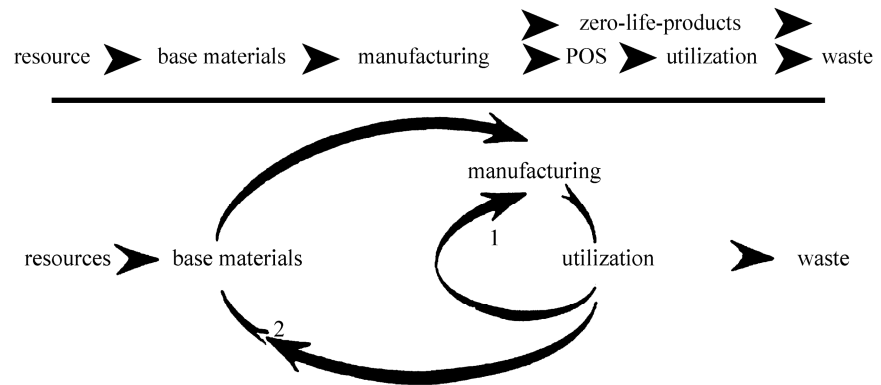


Figure 3: Linear industrial economy versus a closed loop service economy.
Reprinted from [Stahel 1997].

Closed material loops as a central strategy in the service economy

In Figure 3, the upper part symbolises the linear structure of the industrial economy (or *river* economy). The lower part of the figure represents the closing of material loops in a service economy (or *lake* economy). The closed loop flow model representing the ideal of service economy corresponds primarily to the approaches 3 and 4 of Table 2, indicating the possible options of manufacturing industry to reduce material flow related to the manufacturing processes themselves. The inner loop (marked 1) indicates options of direct reuse of systems, products or components in multiple application loops. The outer loop (2) indicates options of materials reuse through recycling systems. Stahel stresses that reconditioning and remanufacturing (1 in Figure 3) is to be preferred to the recycling of materials (2). This is due to the fact (as stated in [Stahel and Reday-Mulvey 1981]) that remanufacturing demands few energy and material resources and large (human) labour investment, while the opposite is the case for recycling loops.

Stahel also discussed the issues of reducing resource flows during products' utilisation phase as in the approaches 1 and 2 of Table 2, but did not visualise these concepts in the same way.

Relating the preceding insights to this thesis, the following conclusions can be drawn from Stahel's, Reday-Mulvey's and the Brundtland commission's contributions:

- The theoretical service economy model promises more effective utilisation of resources through intensified use and multiple reuse lifecycles of artefact products.
- The transition from an industrial to service economy business model must be driven by a visionary commitment. It is characterised by a long term improvement focus regarding the effectiveness of business activities and societal effectiveness of resource consumption.

- There is no indication of directly improved business performance through the transition from industrial to service economy, making the decision difficult for companies and other microeconomic actors.
- Concretising the approaches described in Table 2, the service economy ideal depends on concurrent developments in several dimensions, including:
 1. *Technology* in terms of different materials, components, products, manufacturing and remanufacturing systems, distribution and inverse logistics systems etc.
 2. *Business models* in terms of changed institutional distribution of ownership, usage rights, responsibility and cost distribution.
 3. *User behaviour* as a consequence of the changes in ownership, responsibility, availability and cost.

Eco-Efficient services as prototype for a sustainable business model

2.2 Formation of a new field of research

A central issue regarding the shift from industrial to service economy was identified to be the distribution of ownership, liability and responsibility rights throughout an artefacts life time of activities; i.e. the institutional arrangement between supplier and customer, corresponding to approaches 1 and 2 of Table 2. Under the headline of *Eco-Efficient Services* (EES) a number of researchers approached research into options of reconfiguring business relationship models to achieve the aim of sustainable economic activity. The concept was probably first presented by Bierter et al. [1996], whom also introduced a categorisation of EES in three types, namely product extension, utilisation and result oriented services.

Meijkamp [1998] analysed car sharing systems in the Netherlands (implying these to represent EES business) to conclude on the environmental profile of this business model compared to traditional car ownership models. Meijkamp also presented a general definition of EES, being:

Eco-efficient Services are all kinds of commercial market offers aimed at fulfilling customer needs by selling the utilisation of a product(system) instead of providing just the hardware for these needs. Eco-efficient Services are services, related to any kind of hardware, in which some of the properties rights are kept by the supplier.

[Meijkamp 2000]

Strikingly, this definition does not explicitly mention the aim of reducing environmental impacts through EES. At the time, the emerging research community was still convinced that utility provision through service systems per se would be environmentally preferable to artefact sales based business models, as less products are needed to product an equivalent output (cp. text box on dematerialisation on p. 8).

This misconception has since been corrected through the research projects of e.g. Mont [2004]. Furthermore Hockerts [2008] investigates the theoretical conditions driving eco-efficiency in what is now generally called PSS business models. Hockerts identifies five property right categories as decisive for driving eco-efficiency of service business relations. These are shown in Table 3.

Table 3: Five property right categories imposing incentives for suppliers to improve the eco-efficiency of their offers [Hockerts 2008].

Right and/or obligation to...	Argumentation
share profits and losses	creates incentives to optimise the operational efficiency of products and systems.
maintain and operate systems	creates incentives to optimise reliability of products and systems
dispose of products	supporting the closed loop systems envisioned by Stahel and Reday-Mulvey [1981].
exclude others from use	if the supplier retains this right, sharing and pooling of products and resources is enabled.
use a product	in pay per use type of business models, customers are urged to reduced usage – as opposed to ownership models, where the asset cost is sunk by the customer.

Functional sales as a general approach to service business models

A closely related concept in research is called *functional sales* (FS), which originates in the translation of the Swedish concept *funktionsförsäljning*. The literature on FS is divided into contributions focusing on the business related opportunities of service business models and contributions in particular investigating the options of creating solution systems characterised by reduced resource consumption. A comparison between the different approaches is given by Lindahl and Ölundh [2001]. Another related research concept, which like EES aims for an improved sustainability performance, is labelled *Servicizing* and originates from a report published by the Tellus Institute in commission by the U.S. Environmental Protection Agency [White et al. 1999]. As opposed to EES, which investigates service delivery systems regardless of their link to manufacturing activity, research in FS and servicizing generally focuses on companies shifting strategy from the supply of industrially manufactured products to a service oriented support of these products, while still manufacturing them. Especially the FS concept is defined by the strict requirement that the revenue mechanism employed in the relationship between customer and provider is based on a payment per use, availability or functionality, as opposed to the traditional exchange of product ownership.

Emergence of the concept of PSS

In 1999, the concept of Product/Service-Systems was first introduced in a report commissioned by the Dutch ministries of Environment and Economy. The report by Goedkoop et al. [1999], analyses a number of cases for their environmental and economic properties and defines a Product/Service-System in the following way:

A Product Service system (PS system) is a marketable set of products and services capable of jointly fulfilling a user's need. The PS system is provided by either a single company or by an alliance of companies. It can enclose products (or just one) plus additional services. It can enclose a service plus an additional product. And product and service can be equally important for the function fulfilment. The researcher's need and aim determine the level of hierarchy, system boundaries and the system element's relations.

[Goedkoop et al. 1999]

Just as the quoted definition of eco-efficient services this definition is very broad, and even in the original report restrictions to which services qualify a given market offer to be a PSS are applied. Many of the researchers citing this first definition do question its general applicability and usually apply certain further restrictions in their contributions. Goedkoop et al. endorse the restriction of the general definition through the last statement, thereby underlining that the PSS metaphor is to be regarded as a constructivist concept which cannot be delimited without taking the contributor's aims and approach into account.

Explicit linking of PSS to sustainability efforts

As an example, Mont [2004] adds the elements of actor networks and infrastructure to the definition, while also requiring improved environmental performance compared to what are called traditional business models. From her first publications on the issue [Mont 2000], Mont establishes the concept of PSS as being service oriented business models aiming for minimising environmental impact. Her contribution to the area lies mainly in the analysis of service business cases, identifying drivers and barriers for companies to implement environmentally advantageous PSS businesses. Mont illustrates her understanding of the factors influencing PSS as reprinted in Figure 4.

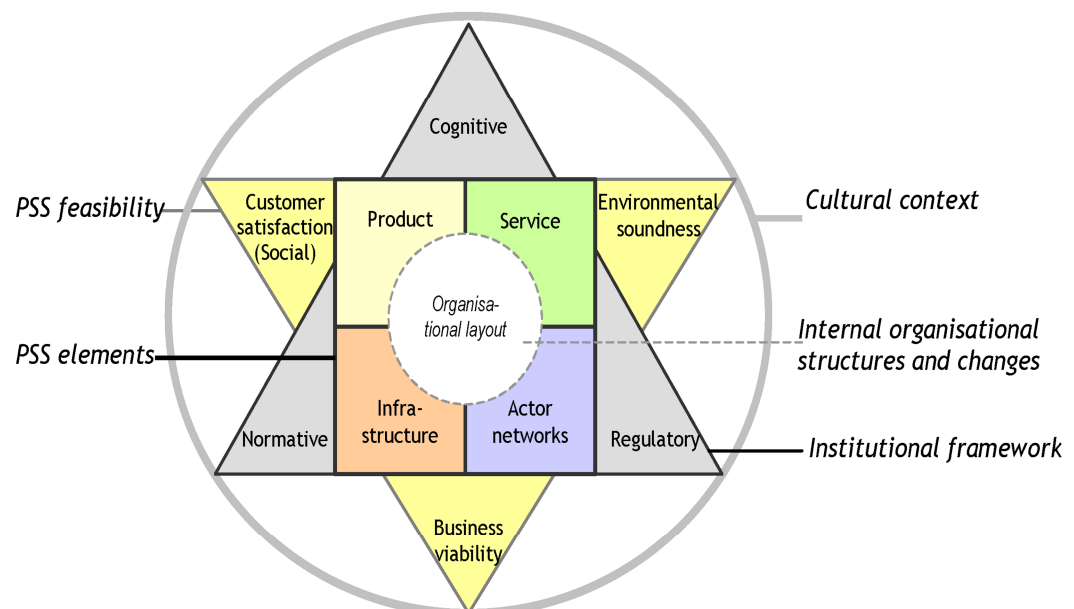


Figure 4: Mont's framework for analysing product service systems. Reprinted from [Mont 2004].

As Mont's objective is the analysis of existing PSS regarding their business, social and environmental performance, she is neither exploring the organisational layout indicated in the model nor the development and delivery systems of the PSS, but merely identifies that the PSS as such is comprised of artefact products (e.g. cars in car sharing businesses) and service operations (e.g. maintenance, inspections, management of fleet capacity), which are delivered by a network of collaborating partners (e.g. financing institution, workshop mechanics, administration company) and rely on infrastructure elements for their utilisation (e.g. roads, service stations and oil companies). In Figure 4 the PSS itself is indicated by the 5 PSS elements.

To make a solution concept a feasible and sustainable PSS, Mont analyses the concept regarding three aspects (indicated by the upside down triangle):

- The individual satisfaction of customers, i.e. whether the PSS can attract users and satisfy their needs.
- The ability of the operation to fulfil its owners objectives, i.e. the business viability which does not necessarily demands for economic profitable results.
- The environmental profile of the PSS compared to alternative solutions, i.e. whether the system fulfils Mont's demand of striving for lower environmental impact.

Finally Mont identifies three institutional framework factors influencing the feasibility aspects and defining part of the cultural context of the PSS:

1. The regulatory context supporting the feasibility aspects by e.g. laws or tax regulations. Regulations influence both the business viability and the customer satisfaction aspects, e.g. dedicated free parking spaces for shared cars in cities, thereby giving utility benefits to customers.
2. The normative context concerns the societal and cultural acceptance of the PSS and its activities. Norms influence the customers perception of benefits as the customers mirror their practices in the cultural normative framework. In some societal groups, the membership in car sharing schemes might thus be evaluated as being progressive and modern, while in others it might be deemed as a symptom of poverty or lack of status symbols.
3. The cognitive context regards the users and peers appropriation [Ingram et al. 2007] of the PSS's functionality and processes. In this respect it is primarily important for the introduction of new solution concepts and their prospective customers understanding of benefits and learning of possible changed practices. An example is how new users of car sharing schemes must get used to planning their transport needs and book resources before departure.

Through the normative delimitation of the concept of Product/Service-System as being a strategy to deliver systemic solutions with environmentally lower impacts compared to traditional business models, Mont is taking a different paradigmatic approach to the research object compared to this thesis. While the historical path of the concept (as described in this chapter) in research is rooted in the sustainability movement, the industrial firm's objectives in development of integrated product and service offers can be of varied and multiple nature. Therefore the systematic and methodical support of PSS development, as aimed for by this contribution,

must be neutral concerning the development objectives, although it is indispensable for a contemporary product development methodology that the evaluation of concepts regarding their societal, business and environmental sustainability performance is supported.

Despite this difference in the paradigmatic delimitation of the construct of PSS, Mont is pointing out important aspects regarding the successful implementation and operation of PSS, as the cultural context of norms, existing practices and regulations are important and can be either driving or prohibiting the successful implementation of specific PSS solutions. Especially in B2C contexts, the normative and cognitive context can be decisive for success, as there usually are offered a variety of similar complementing value propositions in consumer markets. The societal and sociological context of PSS activities must therefore be a centrally considered in any development methodology for PSS solutions.

An outside or customer viewpoint on PSS

Regarding the PSS constitution, Mont applies a user view in describing mainly the elements being delivery vehicles of the PSS value proposition. The issue of organisational requirements is represented in the framework model, but is only shortly discussed. Also the revenue model and distribution of responsibilities is not discussed broadly, as Mont in her thesis assumes PSS to be strictly based on FS type revenue mechanisms. This is in obvious opposition to e.g. EES concepts [Bierter et al. 1996] or the PSS typology of Tukker [2004], which is represented in Figure 5.

Until the beginning of the new millennium, most of contributions concerning PSS and its related concepts are of theoretical or analytical character similar to the work of Mont, meaning that there are no attempts made to support companies or organisations actively in their possible development towards PSS type offerings. The presentation and analysis of existing case companies, such as the car sharing systems described by Meijkamp [1998] can be regarded as support in terms of the presentation of possible best practices, while the first attempts of supporting PSS related development processes methodologically are published in 1998.

2.3 Emerging design support for PSS

First considerations regarding the development of PSS

Hockerts [1998] presents a six-step innovation model to develop EES concepts for companies. The innovation process consists of three main tasks: assigning the team, ideation of service concepts and evaluation regarding eco-efficiency, market potential and user interaction. The presented six-step model seems relatively disconnected from company structures and context, but is nevertheless opening the discussion on how to ideate and conceptualise PSS offers in a company.

Process models for PSS development

With the launch of the fifth EU framework research funding programme running from 1998 to 2002, a number of projects focusing on design and development methodologies within the area of PSS are started, including the *mepss* and *SusProNet* projects. The Product/Service-Systems methodology (*mepss*) project aims for the development of a step by step methodology, guiding companies in the development of PSS concepts. The projects results are documented in a handbook for PSS development [van Halen et al. 2005] and a web based support tool (www.mepss.nl). The *mepss* methodology is structured into 5 phases each subdivided into a number of steps and processes and sectioned by decision gates. Each process includes a de-

scription of objectives, inputs, intended outputs and worksheets to support the process execution by the project team. The methodology is a highly detailed project process model, with instructions on which specific tools (e.g. SWOT analysis) should be used throughout the process. While very detailed and concrete, the mepss methodology similarly to the the EES innovation model of Hockerts [1998] seems disconnected from a company context as there is not made any attempt of matching the methodology steps to the company structure, situation or strategy.

Form May 2002 to October 2004, the sustainable product development network (SusProNet), an EU funded network project aiming for the exchange of experiences and knowledge on product-service development was established to collect the insights gathered through various research projects funded by the fifth EU research framework programme. The research exchange was clustered into five need areas, covering the industrial sectors of material supply, information and communication technology, office spaces, food distribution and household activities and resulted in a number of contributions to the literature, including e.g. [Manzini et al. 2004; Fornasiero et al. 2005; van Halen et al. 2005]. The project outcomes are documented in a book edited by Tukker and Tischner [2006], in which the methods and tools gathered among the networks participants are described and reviewed. One of the results of the SusProNet project is a typology of PSS solutions, which is reprinted in Figure 5. The typology explicitly omits *pure product* (e.g. a pencil) and *pure service* (e.g. legal services) categories of offers as these are not considered PSS.

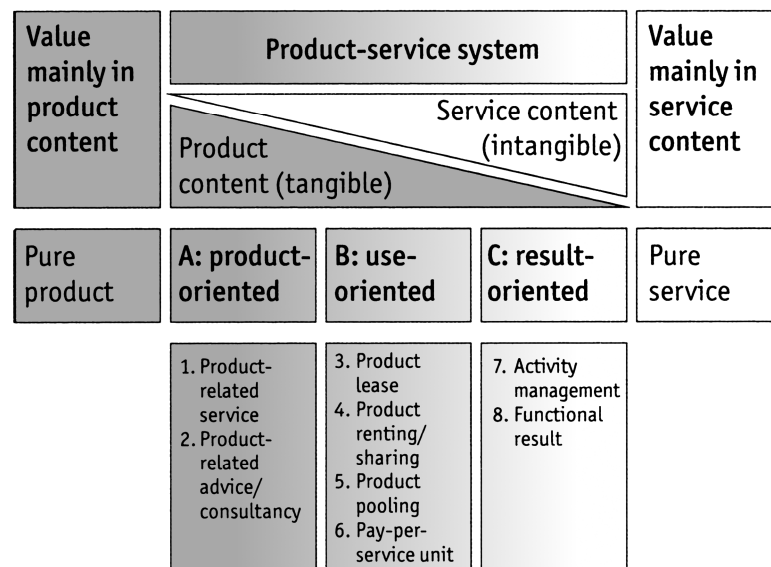


Figure 5: Typology introducing 8 general PSS types [Tukker et al. 2006].

The typology repeats some of the earlier research contributions in being mainly focused on the revenue mechanisms applied to govern the service delivery to the customer, while only briefly describing the character of the delivery system and composition of the offered value propositions (cp. EES on p. 11). In opposition to the delimitations set by Mont [2004], the typology acknowledges that service delivery can be governed by many dif-

Acknowledging PSS to be a profit oriented business model

ferent revenue mechanisms, including services as free benefits added to a traditional product sale model.

In comparison to the analysis focus of Mont, Tukker and van den Berg [2006] emphasise that the development of PSS will usually be aiming for the fulfilment of a broad set of business objectives, which will normally include the requirement of improved profit compared to the existing business model (in case the company is actually utilising the development effort to change the business model of their operation). While the need for profitable operation is obvious for a corporate PSS provider, at least on a medium to long term basis, the argument of Tukker and van den Berg reveals a point of criticism seen from the viewpoint of this contribution: If the development of PSS solutions is considered for an existing company, with existing products and competences within the desired PSS area, the developed PSS will inevitably be coexisting with other offers and business models from the legacy of the provider company's historical path. Therefore the typology of Figure 5 is beneficial in pointing to different options of configuring the revenue mechanisms regarding a product/service offer under development, but the average manufacturing company will probably be obliged and also interested in employing several of the eight PSS types simultaneously.

In general terms, Tukker et al. [2006] define a PSS to be a business model in the sense of Ballon and Abranowski [2005].

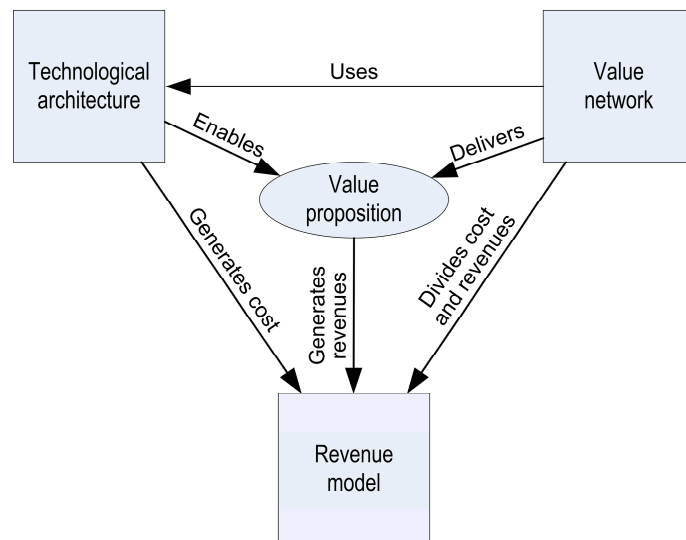


Figure 6: The elements of a business model as proposed by Ballon and Abranowski [2005].

Figure 6 illustrates Ballon and Abranowski's business model construct. Within their framework, a PSS relies on technology architecture (e.g. production facilities and logistics systems) and a value network (i.e. the companies delivering competence and capacity) to be able to deliver a value proposition to the PSS customers. The customers are in return tied into a contract with the delivering value network and generate revenue to be divided between the value network partners.

PSS business model based on IT business model template

The model of Ballon and Abranowski is build on the analysis of internet e-commerce and telecommunication firms, and thus a physical product as

main value proposition element is not considered other than being part of the deliveries of the value network. Instead the value network which is acting as supplier of brokered knowledge or possibly products is emphasised. The primary technological architecture in these businesses will be the soft- and hardware infrastructure which is accessed by all customers on a shared basis, and represents the technological asset of the company. A representation of the product assets of the customers, which could prove relevant for the categories 1, 2, 6, 7 and 8 of Figure 5 seems to be missing in the model of Ballon and Abranowski.

Financial and responsibility issues should be part of the value proposition

Comparing the business model of Figure 6 with the PSS framework of Mont (cp. Figure 4) and the PSS typology of Tukker and van den Berg (cp. Figure 5), it seems misleading that the revenue model is strictly separate from the value proposition. For many PSS solutions (e.g. the car or tool sharing systems described in [Mont 2004]) the payment model is decisive for customers participation in the PSS, thus being defining for the value proposition towards the customer. Taking a car sharing system as an example, the offered vehicles will most likely be financed through a financial institution being part of the value network. This financing service is in effect part of the delivery to the customer, as the customer otherwise would have to invest in the shared vehicles through a (higher) membership fee before using the system services. The same argumentation applies to warranty or insurance type offers, which can be decisive elements for customers in evaluating a value proposition. In conclusion it is important to include at least the part of revenue mechanism which is of concern for the customer into the value proposition, in order to let him evaluate the full spectra of benefits and costs.

Actor Networks are key to the construction of delivery systems and solution concepts

Tukker et al. explicitly frame the task of conceptualising PSS in the following way:

[...] It is useful to conceptualise PSS in terms of a business model approach. This implies that the PSS has to be described in terms of the following questions:

- *What is the offering or value proposition?*
- *Which parties in which roles make up the value network?*
- *Which revenue model is used?*
- *How is the technological architecture organised?*

[Tukker et al. 2006]

Linking back to the conclusions drawn regarding the requirements of the shift to a service economy (cp. p. 10), the research contributions collected and interpreted by Tukker and Tischner [2006] and the contribution of Mont [Mont 2004] add a fourth influential factor to the requirements of service-oriented product development: the explicit consideration of relevant actor networks forming the context of PSS operation.

This active modelling and consideration of the actor networks of delivery is underlined by Manzini et al. [2004], which are documenting the results of a action research project participating in SusProNet. The *Highly Customised Solutions* (HiCS) project applied a design approach to the conceptualisation of collaborative food delivery services, aiming to strike the balance between industrial production efficiency and the delivery of individually customer configured meals to *people with reduced mobility*.

The documentation book emphasises a number of issues that proved central for the realisation of the solution concepts:

- The application of a product family architecture approach (such as described by Harlou [2006]) to the product elements of the system delivery, in order to allow for the efficient user oriented configuration of standard product elements. The product architecture is aligned with corresponding system architecture, executing the configuration tasks of the delivery system.
- The construction of flexible partnerships between the organisations of the delivery network while allowing for changes of both the network partners and the partnership objectives. This is to be achieved through an open structure building on a coordination model that minimises risks through flexible legal agreements and forces continuous open discussion of self interests and partnership aims.
- The consideration of individual customers context components of social-cultural, psychological and physical character, in part mirroring the normative and cognitive institutional framework applied by Mont [2004].

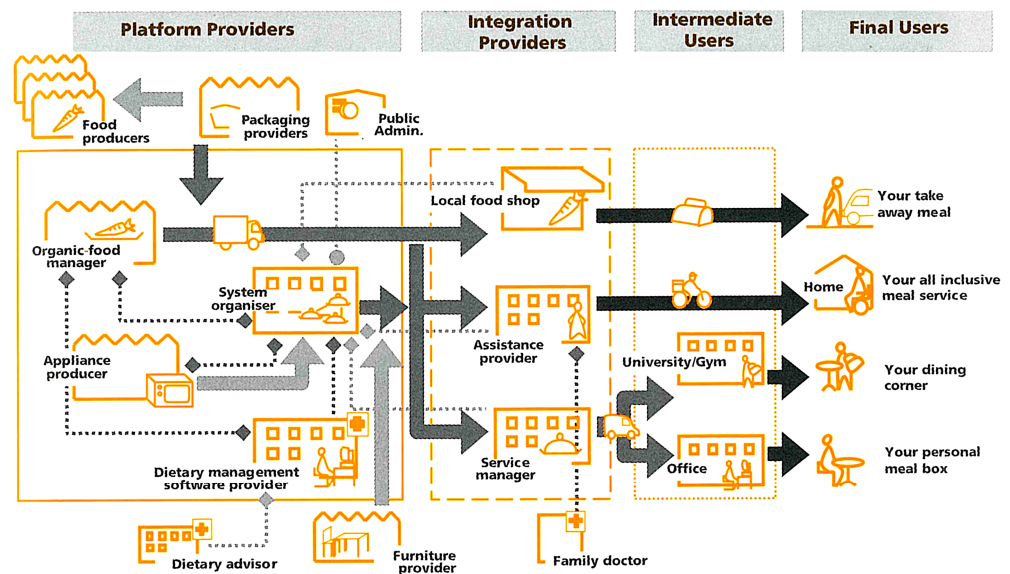


Figure 7: System diagram of *Punto-X*, a solution concept developed in the HiCS project [Manzini et al. 2004].

Figure 7 illustrates one of the developed system concepts, called *Punto-X*. The system relies on the *system organiser* company, which is managing the collaboration of the three other platform providers and the deliveries through the local integration provider organisations. The platform providers deliver the product elements, which in this case are a variety of organic *ready to eat/heat* meal-elements, appliances like vending machines and microwave heaters for use in the distribution centres (*local food shops*, *university/gym* or *offices*) and software solutions that are either embedded in the automatic vending machines or can aid the meal configuration tasks of the *assistance providers*. While the platform providers assemble a delivery package of product elements, delivery services, knowledge systems and concepts for

Networks of delivery

local delivery system implementations, the contracted integration providers are responsible for the localisation of the solution concept depending on their customers/clients needs and context.

The system organiser in effect is the key player in defining how the different partner organisations competence and products are combined to yield the collective solution concept. Even if Manzini et al. [2004] stress the collaborative and evolving character of the partnership, the system organiser will be the primary actor in defining the scope and objectives of the delivery partnership. In their contribution Buganza et al. [2004] point to three main issues that must be discussed and balanced between the collaborating partners: internal payoffs, being the individual partners economic revenue, profit and positioning prospects; external payoffs, being the potential revenues and cost which cannot be directly accounted to the partnership activities (e.g brand equity transferred between partners through the collaboration) and the threats of opportunistic behaviour of partners harming the SOP profitability or operation. Buganza et al. propose that these issues should be solved through renegotiations between all partner organisations in the event of key changes in the network (i.e. introduction of new partners, passing of defined development milestones, in the transition between development and implementation phases of the partnership and in the event of unexpected changes to the partners individual context and business situation).

Context of solution customers

The diagram in Figure 7 indicates how the solution concept balances the requirements of individually localised solutions towards the end customers, with a high degree of industrialisation of delivery systems, in order to combine high levels of satisfaction with high efficiency operation of the delivery system. The diagram also indicates how widely different competences are combined to develop a unique value proposition of organic healthy and convenient meals to a broad group of customers. To be able to customerise solution deliveries to individual customers, Rocchi and Lindsay [2004] identify three main context components, the socio-cultural, the physical and the psychological components, illustrated in Figure 8 as influencing the concrete use process and therefore central for the considerations made in the development of solution concepts.

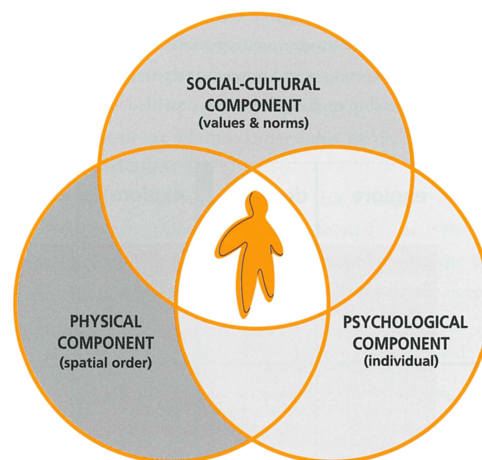


Figure 8: The three context components of individual human actors [Rocchi and Lindsay 2004].

The physical context describes the physical arrangement of the process and the user's position herein. It includes the customer's physical abilities, competence, surroundings and presence of personnel and equipment supporting the utilisation processes. The socio-cultural context of use mirrors mainly the aspects described by Mont [2004] as the institutional framework, i.e. regulations, society and (sub)cultural norms and the cognitive appropriation of the solution delivery process logic. The psychological context of use describes the individual users education, history, past experiences and interpretation of the two other context components. It defines how the transformation results (utility) and the experience of the process is translated to an individual perception of value for the the product user or service receiver. In the terms of a persona description, the psychological context covers personal characteristics like feeling of empowerment, esteem, enjoyment etc.

The outcomes of the HiCS project in general underline the necessity of considering two distinct but connected actor networks:

1. The network of delivery organisations, which is argued to be collaborative in its structure, but in the presented result instances is controlled by one central actor, who is managing the inputs and distribution of benefits to the other partners.
2. The actor networks creating the consumption context and thereby defining the individual aims and needs of the customers.

For PSS delivering to individual consumers or broad customer groups, the consideration of the latter networks seem to be a main concern of the PSS development tasks. The understanding of these networks is crucial to ensure the fit of the solution concept to customers' context components (cp. Figure 8) and thereby ensure that the necessary appropriation investment is limited and customers perceive the solutions value proposition as matching their needs. In PSS oriented towards business customers, the network considerations of the first type are more prevalent, as the customer is in effect closer to being regarded as a collaboration partner and the needs and benefits therefore are more readily negotiable and explicit, as compared to consumer type customers.

	explore	develop	platform vision	explore	develop
partners	Solutions Promoters	Platform Providers		Planned Providers	Solutions Providers
contexts	Contexts-of-Use	Meta-Context-of-Use		Target Contexts-of-Use	Specific Contexts-of-Use
solutions	First Solution Ideas	Solution Platform Elements		Proposed Solutions	Partner-Based Solutions

Figure 9: The Solution Oriented Partnership Methodological Framework and the intended use phases of the design plan templates within it [Meroni 2004].

Regarding the development of the solution, the HiCS project proposes the *Solution Oriented Partnership Methodological Framework* (SOPMF) and some eight to ten tools and documentation templates, which are to support the development partners in solving the various tasks of the concept and partnership development project.

The SOPMF models three rows in Figure 9 illustrate the three main development themes as they were identified in the HiCS project, being the definition of a delivery partner network, the identification of the user context, needs and possible value propositions and the definition of the solution concept in terms of product and delivery process elements. The four columns represent the phases of development, starting from the initial identification of options, through the development of a concept and the evaluation of concept fit and possible gaps to the finalisation of the solution concept.

Narrow focus of PSS design contributions

All of the approaches to PSS described in the former sections have focused on the consumption area, i.e. the solution offered and the operational properties of that solution. Although Tukker et al. [2006] describe PSS as being essentially equivalent to the business model construct of Ballon and Abranowski [2005], the tools and methods of development and analysis focus narrowly on offer design [Manzini et al. 2004] (i.e. the solution concept) or environmental effects [Mont 2004] (i.e. comparison of developed solution concepts and similar solutions existing on the market).

One of the fundamental strategies leading to research in sustainability driven PSS were the service economy principles of Stahel [1997], as seen in Table 2. The principles of *sufficiency solutions* and the *more intensive* and *longer use of material goods* are targeted by researchers in PSS development, as they claim PSS allows the delivery of individually contextualised and sufficient solutions to a broad range of customers [Manzini 1999]. To fulfil this claim, firstly the provision of a sufficiency solution must be flexible to allow for a change in user's needs throughout their life, and consequently the solution and delivery system must evolve to continuously be matching the needs of users (unless the changing needs remain within the flexibility of the initial PSS offer). Secondly, the more intensive and longer use of material goods requires both the implementation of maintenance and remanufacturing systems [Sundin and Bras 2005] and the introduction of a flexible product and remanufacturing platform to allow long term economic feasibility and continued development of product functionalities.

Both arguments point to the necessity of managing the continuous development of the PSS, i.e. the PSS solution is closely bound to the provider's corporate development and must be developed in consideration of both previous and future PSS generations. In relation to these requirements, the contributions presented in the previous sections seem to have been too narrowly focusing on the single development project and only rudimentarily linking to issues of corporate strategy and development management.

2.4 A business management perspective on PSS

In Section 2.3 Tukker et al. [2006] describe PSS to essentially be a specific business model, based on a value proposition of products and services delivered by a network of providers and turned into business utilising a specific or sometimes several parallel revenue mechanisms. In effect, the development of PSS therefore equals the development of a business model. Chesbrough and Rosenbloom [2002] largely agree on the compositional elements of the business model construct, which they propose should explain the following six main issues: value proposition, market segment, value chain, cost structure and profit potential, value network and competitive strategy.

The development of a suitable business model is a success factor equal to mastering a core technology

They argue that the business model of successful firms remains fixed, and later technology additions only difficult can break free of the legacy business model unless explicit efforts are invested into it. Their argumentation is based on an analysis of a number of spin-off companies from Xerox PARC, a corporate research institution of Xerox Corp. In their case analysis, Chesbrough and Rosenbloom describe a number of potentially successful technology ventures, and point out how the effectively successful ones prevailed mainly because they were able to break free of the parent company's legacy, regarding the constitution of their business model. Additionally Chesbrough and Rosenbloom point to the cognitive effect legacy business processes have on managers and employees, making it difficult to organise new radically different business units within the framework of the existing company. The closer the link to the existing business processes is, the more easily is the new business measured according to established standards, and thus in the danger of not finding its own ways.

The value chain concept

Porter [1985] models the company as an assembly of functional units, each contributing to the total value creation of the company's products, as graphically represented by the model in Figure 10. Through the differentiation from competitors and the optimisation of the different functional operational units, the company gains competitive advantage, which is included in Porter's generic value chain model as the margin that customers are willing to pay for the company's products, on top of the delivery functions cost.

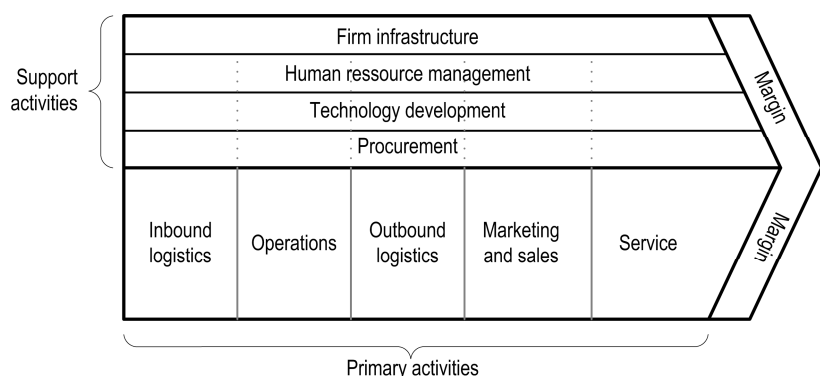


Figure 10: The generic value chain model of Porter [1985].

In comparison with the contribution of Chesbrough and Rosenbloom [2002], Porter strictly adheres to the general business model of procuring assets, adding value to them through a number of *primary activities* and then

selling the finished product at a margin to customers perceiving the value added by the company to be larger than the added cost of company activities. This logic seems tailored for application in mass manufacturing companies, but according to Porter it can also be applied to other business models through the adaption of the relevant functional units. The underlying principle is the discourse of focusing operations on few but critical operations, where the firm can retain or build competitive advantage, while separating other operations to external partners in the so-called value system or internally in other business units having their own value chain setup. Porter [1985] acknowledges the issue of possible interrelationships between value chains internally in a company or externally between companies, but largely dismisses the potential of creating synergy effects between separate value chains as being unlikely. However, the implementation of interrelations between business units is evaluated as positive in respect to three issues:

1. If there are *tangible* benefits from the sharing activities like e.g. (business) channels, technology or capacity etc. An example could be the shared production facilities of business units manufacturing jet-ski and snow-mobiles, as the two product type have opposite sales seasons.
2. If there are *intangible* benefits from the sharing of know-how between separate value chains. An example could be a shared marketing management for televisions and radios, being sold to comparable markets and through the same channels.
3. If the company is facing competitors covering the same markets and product types, the joint fighting of common competitors can be beneficial. This type is called *competitor interrelationships*.

Although well known and applied in many industries, the value chain concept has been discussed regarding its applicability in many of the emerging network and information based markets [Armistead and Clark 1993]. Definitely in tele- and internet communications, the creation of value often is not depending on the activities within the value chain of the provider, but merely is created through the network externalities emerging through the building of a common shared network between users. An example of this could be currently emerging internet business models such as utilised by e.g. flickr.com. Flickr is an image sharing service based on membership fees paid by co-called premium members. The growing community of users triggers members to become paying customers in order to enable them to share more photos and send messages to other members. The service builds competitive advantage on a communication infrastructure that allows the shared value creation between members, which are not themselves part of the value chain.

Based on their perceived inappropriateness of the value chain model to describe competitive advantage in many emerging industries, Stabell and Fjeldstad [1998] propose two alternative models for the representation of the so-called value configuration. Stabell and Fjeldstad offer the alternatives of the *Value shop* and the *Value Network*.

The value shop and value network as alternatives to manufacturing value chains

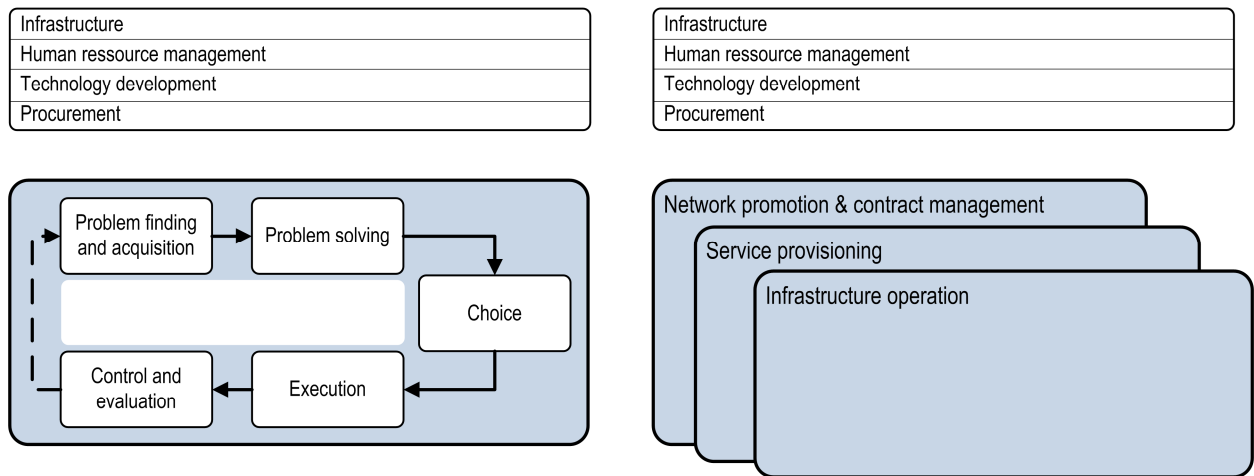


Figure 11: The two alternative value configurations of the company, the value shop on the left, value network on the right [Stabell and Fjeldstad 1998].

While Stabell and Fjeldstad [1998] retain the support activities identified by Porter [1985], the structuring of the two alternative value configuration models is reflecting the main tasks of their respective business. In the value shop, the main tasks are the solving of customers individual problems, which is achieved through the application of a cyclical process of acquiring the task, developing solution concepts, choosing the preferred concept, executing or implementing the chosen solution and evaluating the outcomes. In the value network configuration, the main tasks are the provision of an infrastructure platform, the operation of service delivery systems on the platform base and the management and development of the network.

Configurations illustrate the chosen business model, but are incompatible in terms of strategic comparison

While the configurations of Stabell and Fjeldstad [1998] seem more applicable to some types of business models, e.g. the image sharing service in the example above, the claim that one of the three representations would be fit to describe any imaginable business model seems unlikely. A thought example imagining a manufacturing company offering technical sales services to the customers of their product, would already call for the division of the company into two separate business units with separate value configurations. While the manufacturing unit would be adhering to being represented by a value chain model, the sales support would require a value shop configuration.

The modelling principle also seems to differ between the three configurations: as personnel in the value shop predictably would follow the progression of the problem solving cycle; the manufacturing value chain relies on the functional rootedness of the company resources. In conclusion, the three value configuration models of Stabell and Fjeldstad [1998] are suitable for the general description of a business units value generating mechanism, but are not applicable to the formation of competitive strategies for advantage as the traditional value chain concept is within manufacturing industries.

Drivers supporting the diversification of business activities into service delivery

Araujo and Spring [2006] compare and discuss some of the contributions in literature on the strategic shift of manufacturing companies to service provision. They identify three of the main drivers to be:

1. The growing installed base of systems in mature industries causes diminishing sales growth potential, while after sales opportunities arise [Wise and Baumgartner 1999].
2. The increasing complexity of technical systems and concurrent customer focusing towards core competences open opportunities of solution selling, i.e. service offers in pre-sales and installation phases [Davies and Brady 2000; Davies et al. 2007].
3. Recent innovations in organisational performance management (e.g. *activity based costing* accounting methods) drive companies towards closer measurement of smaller functional and competence units within the firm, eventually causing the identification and isolation of specific socio-technical capacities that are offered as services both internally and externally [Zenger and Hesterly 1997].

Accounting and performance measurement creating customer focus on sub unit level

While all three drivers require organisational and strategic changes of the company structure (and are discussed in the following paragraphs), especially the third driver can lead to a (partial) organisational disintegration of the company, as illustrated in Figure 12. Through the implementation of individual fine grained performance measurement, internal units can be benchmarked against external competitors. Eventually single business units might be encouraged to provide external services or activities and will encounter external competition in supplying internal customers.

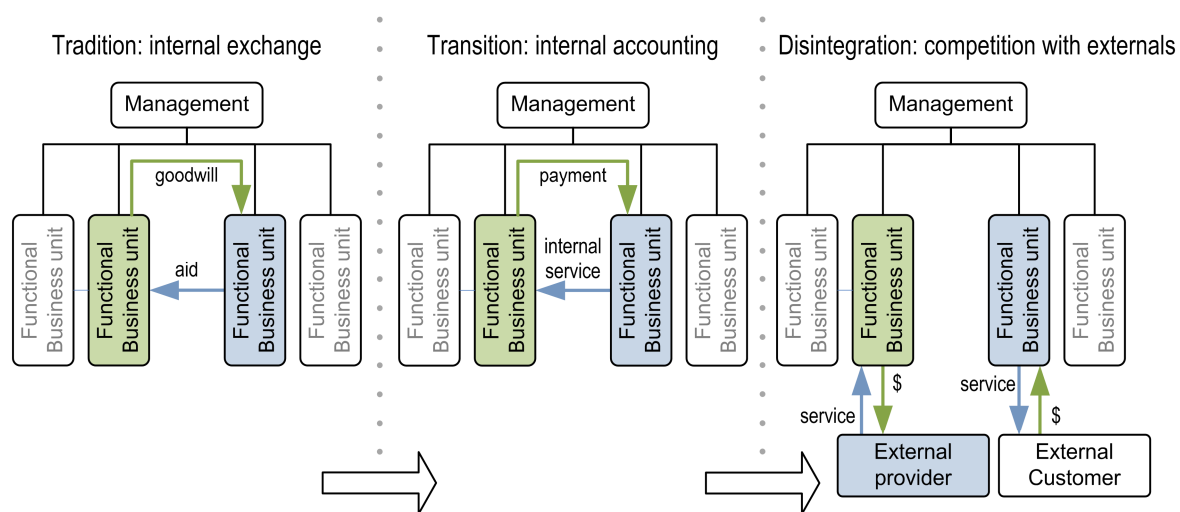


Figure 12: Management technologies driving company towards disintegrated structure. Based on [Zenger and Hesterly 1997]

A concrete example of this development is the Danish medium size textile supplier Gabriel A/S. As indicated in the organisational diagram in Figure 13, the company has chosen to disintegrate into 17 independent strategic business units. Most of these are encouraged to isolate their specific service offers and cooperation between units is done at arm's length and in competition with external suppliers. Considering the company's total staff of less than 150 employees, the chosen strategy is rather unusual.

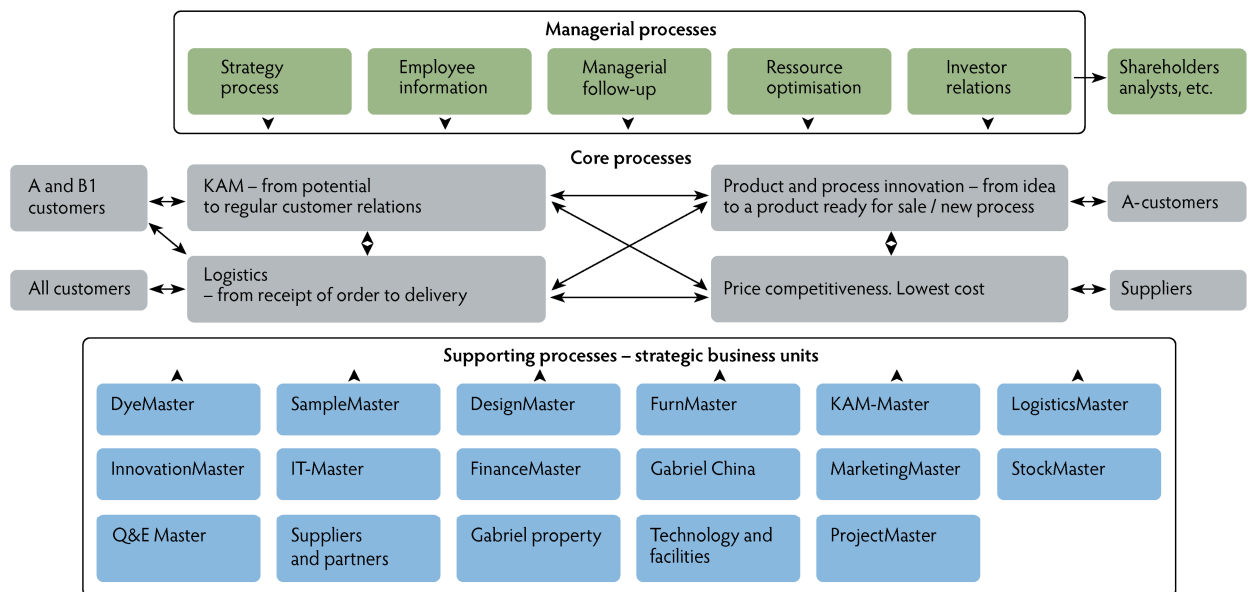


Figure 13: Example of a strategically disintegrated company. Organisational diagram of Gabriel A/S [Gabriel A/S 2007].

Dedicated service life support organisation

Foote et al. [2001] describe the shift from manufacturing to solutions and service delivery from an organisation management point of view. Presenting different examples of firms moving from product and manufacturing focus to a service or solution delivery strategy, they point out the management challenges these companies have overcome in the process.

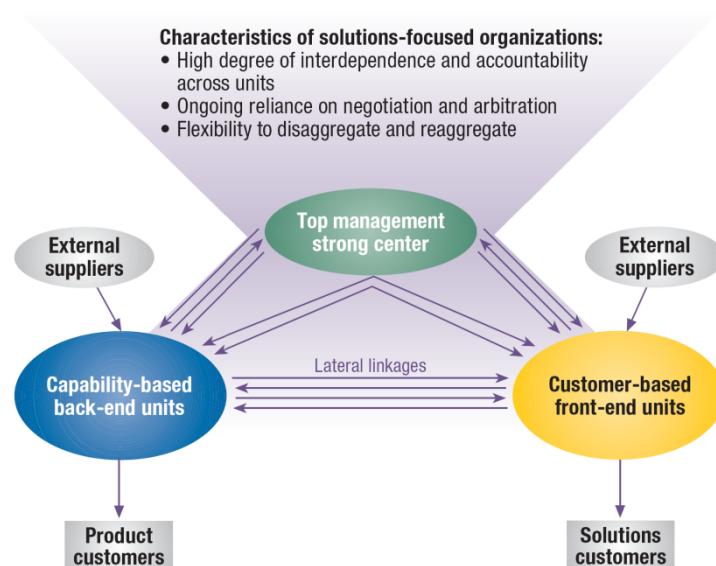


Figure 14: Strategic division of the service oriented manufacturing company into a front end, a back end and a management unit. Reprinted from [Foote et al. 2001].

Figure 14 illustrates how Foote et al. describe how companies entering service oriented business from a legacy of manufacturing products implement a strategic division of their organisation into three functionally different units. Foote et al. argument that the product manufacturing unit (back-end)

should be isolated from a growing customer servicing (front-end) unit, to allow them to further support existing markets and maintain their performance management systems which are optimised for a manufacturing oriented operational and management structure. The front-end delivery units on the other hand must be allowed independency from the manufacturing unit's products, in order to enable them to deliver optimal solutions to their customers. The so-called *strong centre* takes responsibility for ensuring lateral interaction, creation of synergy and the correct arbitration of performance appreciation and resources. In a study covering 30 organisations Miller et al. [2002] confirm the findings of Foote et al. regarding the advantages of dividing the company into three individual organisational units as described above. In effect Foote et al. [2001] adhere to the value chain logic of Porter [1985] described above, where the firm deliberately creates a second business unit with the purpose of customer support. The two business units each build their separate value chains (or chain and shop) and focus operations in order to achieve competitive advantage.

Division of front- and back-ends based on the requirement of focusing on delivery efficiency and customer closeness respectively

Foote et al. base their recommendations on the analysis of companies, which front end activities target few but large business customers (e.g. delivering power plants, corporate IT-systems etc., telecom infrastructure etc.). The Front-end units are organised as flexible customer teams, gathering the needed competences for the specific contracted projects, in order to fulfil the individual customer's needs before reorganising for the next contracted customer. The customer teams also assume responsibility for the individual customer account and thus are measured regarding their profitability on a case by case basis.

Development through industrialisation of successful projects

Davies and Brady [2000] underline the need of dividing projecting tasks from product related tasks, and agree to a company structure with three units. Regarding the development of (projecting) services, Davies and Brady take the approach of linking service development to organisational learning of the customer service units. They propose a four stage process, starting with the strategic choice of piloting a new project type, customer group or technology with a single customer. Based on the experiences of this first customer relationship, knowledge is transferred to subsequent projects and relationships, which benefit from the experiences build earlier. If the new service offer proves profitable and a growing market is identified, the delivery organisation is adapted to the continuous and parallel delivery of the new service offer to several customers. Finally a dedicated delivery organisation is defined separate from other units if the business area can sustain the necessary volume.

Similarly, Foote et al. [2001] also touch the issue of developing solution elements in order to yield synergy effects from the firm's combination of manufacturing and servicing competence. The development approach is illustrated by the example of IBM. In IBM an integrative leadership team analyses the single customer specific solution concepts as potential candidates for inclusion in the future standard offer portfolio. The development process and its changing organisational owners are illustrated in Figure 15.

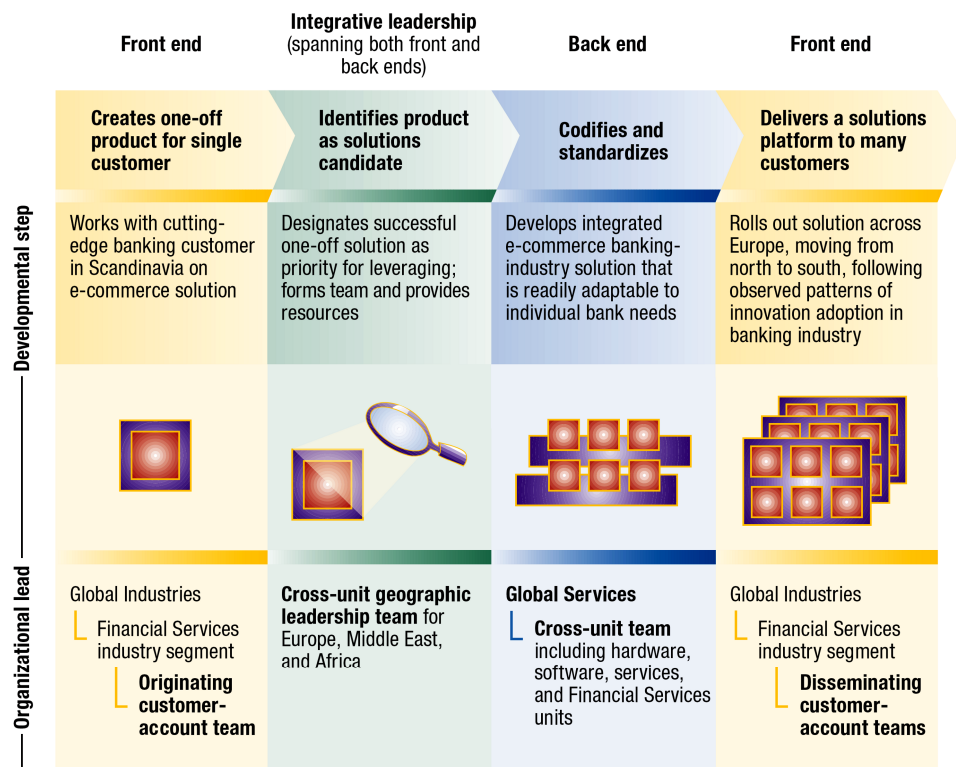


Figure 15: Example illustrating IBM's process of transferring a specific customer solution concept to the general offer portfolio. Reprinted from [Foote et al. 2001].

The advantage of this approach is that all potential standard solution concepts are developed in close collaboration with key customers and the selection of candidates for standardisation therefore can be based on implemented and operational *solution prototypes*. The development risk is minimised, as the concept already has proved its performance and the development cost are mainly carried by the collaborating partner.

The challenge in the development process is to turn the specific solution into a generic offer and restructure the existing system into a rationally configurable solution concept that can efficiently be implemented in other contexts.

Compared to traditional design approaches, the approach represented in Figure 15 lacks dedicated idea generation phases. The needs initially expressed by the first customer and after negotiations transferred to the specifications of the prototype solution are defining for the performance and functionality of the later standardised solution. This implies that the innovation level of new solution elements depends highly on the risk perception and readiness of both the primary customer and the dedicated customer team co-developing the pilot solution concept. The approach also reduces the ability of transferring solution concepts from the original key account market segment [Porter 1985] to other segments, as needs in other market segments will be considerably different, and customers in these segments only seldom will be interested and able to invest in the solution development themselves.

The cases and principles presented by Foote et al. certainly are focused on the specific area of key account services for capital investment offers.

Innovation depending on customers' ambitions

Cohen et al. [2006] describe the area of product related services in general, and proposes seven after-sales models similar to the PSS categorisation of Tukker [2004]. For the development of their so-called service networks, Cohen et al. propose the systematic six step approach in Table 4, which differs significantly from the dedicated standardisation approach presented by Foote et al. [2001]:

Table 4: Six step development approach to after-sales services [Cohen et al. 2006].

Six steps for managing service networks
1 <i>Identify which products to cover.</i> Support all, some, complementary, or competing products.
2 <i>Create a portfolio of service products.</i> Position service products according to response times and prices.
3 <i>Select business models to support service products.</i> Use different models for different products and life cycle stages.
4 <i>Modify after-sales organizational structures.</i> Provide visibility, incentives, and focus for services.
5 <i>Design and manage an after-sales services supply chain.</i> Decide resource location, prioritize resource utilization, and plan for contingencies.
6 <i>Monitor performance continuously.</i> Evaluate against benchmarks and customer feedback.

Straightforward method for maintenance service development

In comparison with the process of Foote et al. in Figure 15, the approach of Cohen et al. is focused on the direct support of the company’s physical products, but in turn covers a much broader range of possible customer segments. Unfortunately, the description of Cohen et al. covers mainly the organisation of spare-part and maintenance deliveries, and does not consider how use phases activities can be optimised from a customer viewpoint or how the service delivery efficiency can be supported by the adaption of products to service systems. Cohen et al. also omit descriptions of how solution concepts can be synthesised using the six-step approach, and instead describes a number of concrete examples to elucidate decisions taken in each step, most of which again regard the setup of spare-parts delivery systems.

Acknowledgement of integration synergy

Davies [2004] underlines the additional options emerging to firms that both develop products and operate them throughout their service life, i.e. offer PSS solutions. Davies describes the case of Alstom Transport, which had the opportunity of drawing on the company’s internal operations units when designing the rolling stock for the extension of an underground line in London. Based on the experience of the maintenance and service operations managers, the company could make over 250 modifications to earlier designs, in order to yield trains that were easier to use and maintain. In his case study, the mechanisms of feeding back knowledge from the delivery to the development organisations in the firm are not described, but the advantage of having the closed feedback system is underlined as an advantage compared to service providers lacking the products development and manufacture competence.

On a theoretical level, the issue of feeding back information from the service life phases of one product generation to the development of the next have been explored within the field of product development research.

2.5 Product development models

One of the recent larger research projects in the area of product development was conducted by the Finnish research agency in collaboration with Finnish industry [Malinen 2000]. The so called RAPID –project resulted in general product development model that covers and positions some of the influential contributions in the field of product development methodology.

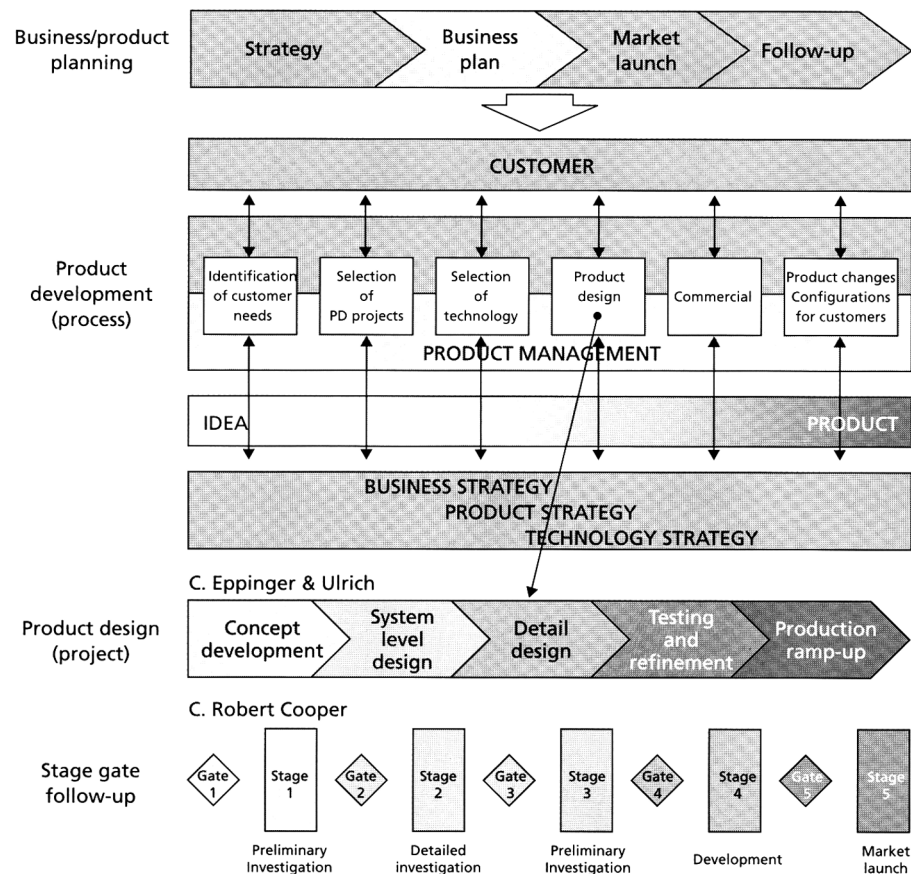


Figure 16: The hierarchy of the development system [Malinen 2000].

In Figure 16 the lower two rows illustrate the core product design task, which in the figure is governed by a phase-gate project management system. The design task is part of a larger development system that is consisting of both project-based and continuous tasks.

This division of the development system into episodic projects and continuous functional tasks has also been investigated by Miller [2001], who is presenting a framework for modular engineering, that proposes the division of both products and engineering tasks into an architecture that allows the rapid development of individually contextualised technical systems. Miller's approach, just as later contributions in the field of product architecture (e.g. [Harlou 2006]) are interesting for the conceptualisation of PSS, as the creation of standardised engineering tasks in effect is equivalent to the creation of a flexible, yet efficient engineering service system.

Design research not considering appropriation processes

2.6 Product development management

Regarding the development of products, Ingram et al. [2007] point towards an important shortcoming of most design research, rooted in the common focusing of research on the single design or development project. Figure 17 illustrates their basic argument regarding the design process. Although being framed as a defined project for reasons of resource management and progressing from stated project goals to accomplishment, the development process in the wider view is only part of a cyclical progression alternating between processes of design and formation of use practice.

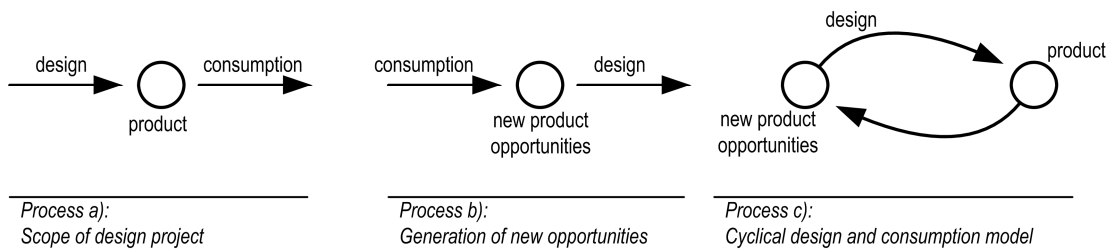


Figure 17: A model describing the cyclical process of design and consumption. Redrawn from [Ingram et al. 2007].

While Ingram et al. base their argumentation on physical artefacts and consumers' creation of general use practice regarding these goods, the necessity of considering the cyclical process of design and use is generally applicable for any technology (artefact or process based) and customer relationship (consumers or businesses). Ingram et al. stress that customers, when engaging in the use of new artefact products, will appropriate them to match their use practices and expectations. Therefore the delivering company cannot predict how their products will be used, before they have been adopted by the market and specific practices have emerged.

Different timescales of product and business development

However, the two cycles of design, appropriation and emergence of practice within the frame of this thesis seem to be proceeding asynchronously, and in industry the problems touched by Ingram et al. are attempted mediated through the application of product planning and portfolio management approaches.

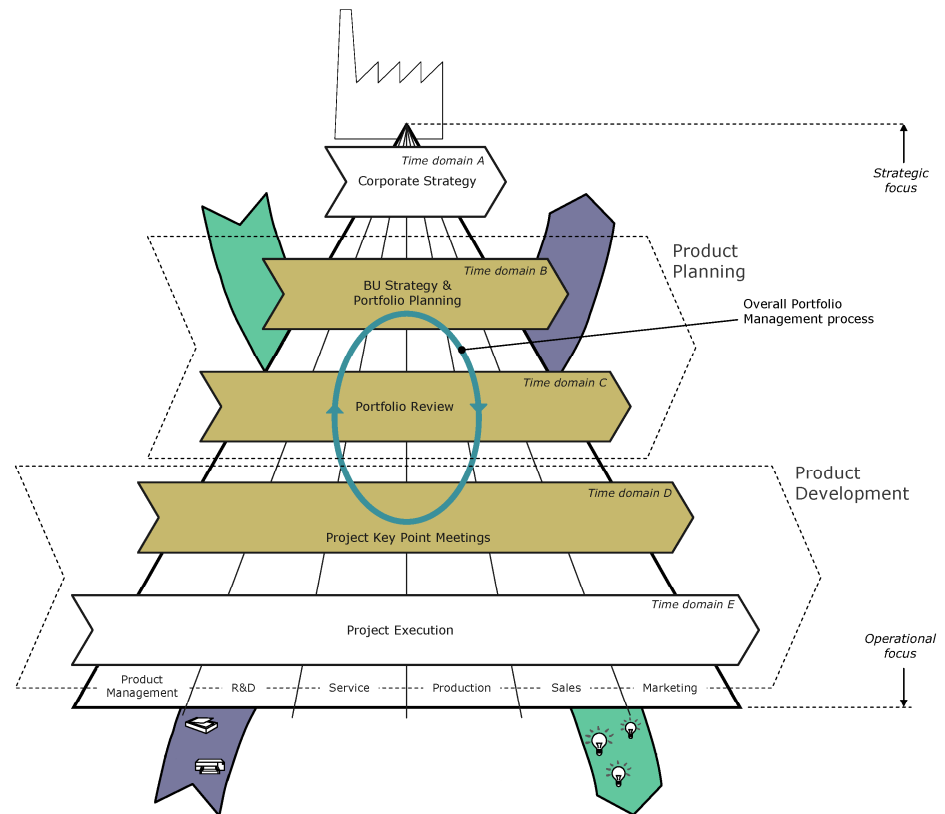


Figure 18: Larsson's reference model for corporate portfolio management.
Adapted from [Larsson 2008].

In this sense, the cyclical process of Ingram et al. is comparable to the returning corporate processes of reviewing current strategies on the corporate and functional levels and defining development portfolios and road maps for short term and medium term development of the company. A recent reference model for manufacturing companies developed by Larsson [2008] is reprinted in Figure 18.

Larsson's model is divided into an upper part, representing the functional division and decision levels of the industrial company, and a lower part showing a representation of the portfolios emerging as the result of the planning and management processes coloured in sand. Knowledge of market, competitors, customers, legislation and trends influence the company management processes, which operate within time frames ranging from several years for the *corporate strategy* level down to days, weeks or months for the *project execution* tasks. The indicated cyclical portfolio management process is assumed to draw in the knowledge and experiences regarding the changing practices, needs and expectations of customers, in order to allow the definition of development projects leading to relevant and well performing new product generations.

The result of the portfolio management process is depicted as an overview plan of three portfolios, being the portfolio of current products, the portfolio of current projects and the portfolio of current ideas and project proposals. For the two former ones there additionally exists a vision of the ex-

Emerging additions to the model for the use in a PSS context

pected future products and projects – depending on the feasibility and success of executing the planned current projects and ideation processes.

Considering a PSS providing company, there seem to be the need of expanding the model of Larsson in a number of aspects, as it is strictly considering the tasks of product development.

In his thesis, Larsson underlines that other development projects of the company might be conducted in parallel with the scheduled product development projects, and taking the insights of section 2.12.1 into account, the main tasks of service development will be related to the building of delivery systems and infrastructure, thus resulting in projects of a different character compared to product development projects. Examples could be necessary knowledge management systems representing an internal process and IT support project or the building of regional service or maintenance capacity which would imply the attraction, employment and training of personnel as well as investments in real estate and technical equipment.

Furthermore the life cycle support of products in a PSS business model means that past products might be sources of development projects after their manufacturing and sales have been suspended. An example of this is the driver support of legacy products by most hardware manufacturers, implying the need of developing driver modules for new computer and operation system generations.

2.7 Product life considerations in product development

The theory of dispositions

In his thesis, Olesen [1992] is investigating how the decisions of the product designer is influencing the resulting product's properties and performance throughout its life. Olesen defines the concept of disposition in the following way:

By a disposition we understand that part of a decision taken within one functional area which affects the type, content, efficiency or progress of activities within other functional areas.

[Olesen 1992]

Andreasen et al. [1989] illustrated the mechanism of dispositions as shown in Figure 19 below.

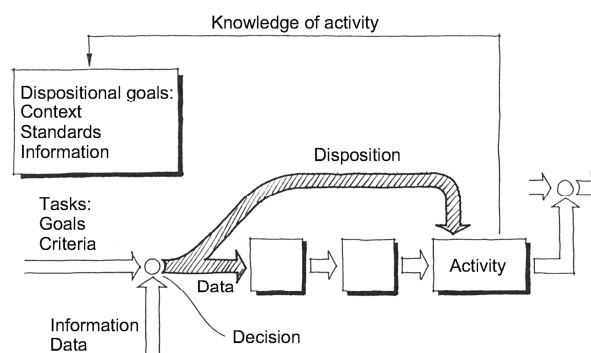


Figure 19: A graphical model visualising the mechanism of dispositions.
Translated from [Andreasen et al. 1989].

In the definition, the term functional area refers both to the task and organisational distribution within the manufacturing company, e.g. a design decision taken in a product development project affecting the choice of possible sub suppliers for the procurement department. Generalising the dispositional mechanism further, Olesen later forms the disposition mechanism into a general theory of dispositions, which explains the relationship between the development, performance and effects of activity systems throughout the life of industrial artefacts. The theory is illustrated by the so called score model, which is reprinted in the Figure 20 below.

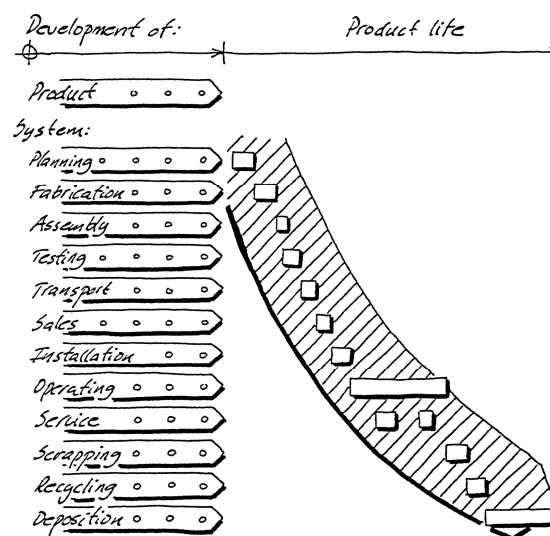


Figure 20: A score model which gives an overall view of all systems which dispositions affect when a product is developed. Reprinted from [Olesen 1992].

The product developer orchestrating the prospective product life

The score model earned its name through its likeness with the score guiding an orchestra's conductor by showing the orchestra's individual instruments' notes on a single sheet of paper. In the top left of the model, the development project leading to the definition of the product in question is symbolised. Below it the (potential or possible) development projects preparing the different subsequent life phase systems the product passes through are equally symbolised. The right side of the model symbolises the actual product life, where the product goes through various product life phase systems participating as actor in so-called life phase activities. The dispositional mechanism implies that both the decisions made in the development of the product and the decisions made in the preparation of any life phase system will influence the properties of all subsequent life phase activities.

Example of dispositional mechanisms

As an example, an automotive company might develop a new model in their line of family hatchbacks through the execution of a product development project (top left process in the model) based on the platform of the model currently in production. Concurrently, or probably with a slight time lag, there will then be developed a production system (fabrication process in the left of the third row of Figure 20) for the new model, adapting the current production lines for the new model and contracting sub suppliers to e.g. design new stamping tools for the future car body's panels. Many of the other life phase systems will probably not require changes to

be able to cope with the current and the future model, and thus will not undergo any development. Once the new model is released, every instance (car) produced will pass through the different life phases (indicated by the hatched arrow on the right in Figure 20), where the product instance (car) will become one of the actors in the network of activities making up the life phase system and its activities.

Olesen focuses his research on the product life systems and phases which traditionally lie within the responsibility of the manufacturing company, i.e. the phases which in the model are categorised from planning through to transport, sales or installation, depending on the type of product and business model in question. Nevertheless Olesen is pointing to the following issue in his final conclusion, which is central to the research in this thesis:

In many research areas, the product is considered from cradle to grave. The chain effects arising from the product which are to be explained here are also described by the theory. The theory of dispositions will here be able to contribute with general patterns of description.

[Olesen 1992]

Recalling the first quote of Olesen on page 34, the decisions taken in the development of the product will affect the resulting products properties when it becomes actor in subsequent life phase systems. The traditional approach to product development is to analyse existing life phase systems the product is likely to participate in, in order to ensure that the product exhibits suitable properties when the product life phase system is actually invoked.

Although this approach has been relatively successful in optimising products and their performance, there is another option visible in the score model of Figure 20: The life phase system itself can be developed, changed, adapted and optimised to yield the best possible performance of the life phase activities. It is actually what has been done in the above example, where the life phase system of production is developed and adapted to the new car model's requirements. As Olesen notes in his conclusions (see quote above) in principle all life phase systems are flexible and can be adapted, still subject to the mechanism of dispositions, but in general, manufacturing companies have refrained from influence in the life phase systems of use but focused on the phases they per se were responsible for, i.e. sourcing, manufacturing and marketing.

Anticipating the step into actively designing the products service life, Kimura and Suzuki [1996] are taking up the challenge to transfer the strategy of dematerialisation and the shift towards a service economy into product development practices. Kimura & Suzuki promote the concepts of a *Right Quality Product* (RQP) and *inverse manufacturing* as means for this transfer.

The *Right Quality Product* concept is a metaphor for products which can be reconfigured repeatedly throughout their (long) service life through a modularised design, where functionality modules can be added or removed according to any individual user's current needs. The spare modules of the RQP are in effect to be shared between all RQP users through a reuse and eventually a remanufacturing system. The RQP in that way corresponds to a product where dispositions are made to ensure optimal properties

Developing the product life before the product

Preparing manufacturing systems for a
lake economy

throughout a prolonged service life, supported by pre-planned recycling loops.

The *inverse manufacturing* concept was coined by the design researchers community in Japan (e.g. [Umeda and Tomiyama 1996]) and represents the means of realising closed material loops through reconfiguration and reuse of components, product subsystems or complete products (cp. the reuse loop (marked 1) envisioned by Stahel in Figure 3). Inverse manufacturing covers the development and implementation of life phase systems capable of supporting the envisioned RQP by enabling the closing of material loops between different users, products and life phases.

The RQP and the development of matching inverse manufacturing life phase systems still represent a mindset of a manufacturing company providing a physical product, which is then utilised in life phase systems primarily controlled by the company's customers or the product's users.

Design for Environment efforts as first
step to consider use process
optimisation in product development

Throughout the 90's, a number of research projects were conducted to reduce the environmental impact of industrial products through redesign by applying Design for Environment methods such as documented in e.g. [Olesen et al. 1995]. The main focus then was initially on materials, manufacturing processes and the consideration of products properties in disposal life phases, as these issues reflected industry needs of prioritising the resource consumption and environmental impact they themselves were accountable for. Departing from that path, Hansen [1997] explored the importance of use phase activities for the environmental effects of products throughout their life cycle. He identified three main factors influencing the environmental performance of products: the products technical performance; the user's utilisation and operation practices and the influences of other processes linked to the activity, i.e. the life phase system. As an example, the total environmental emissions of an office printer system is not only depending on the printer technology in terms of toner and energy use per printed page, but also whether users print duplex prints thereby halving the paper consumption (i.e. the use practice) and what type of paper is used to feed the printer (as material, energy and chemical consumption in paper production varies considerably). In effect, the environmental, as well as other user related properties of the product are relational and depend on the life phase system and user (or other actor's) activity practices

Figure 21 illustrates how the product participates in multiple activities throughout its life cycle. Linking this insight to the theory of dispositions, product development must evaluate all life phase systems, identify and select the activities most influential for meeting specified target properties of the product, and ensure that product, life phase system and involved actors interact optimally.

Use activity must be optimised both for
user satisfaction and process
performance

Figure 21 in part covers the same influence factors as illustrated in Figure 8, but does so from a different viewpoint. While Rocchi and Lindsay [2004] focus on the users perception and evaluation of the activity process he is involved in, Hansen [1997] evaluates the environmental process results. In the same way, results related to other performance dimensions, e.g. the 7 universal product virtues cost, quality, time, efficiency, flexibility, risk and the aforementioned environment [Olesen 1992] could also be linked back to the single activity.

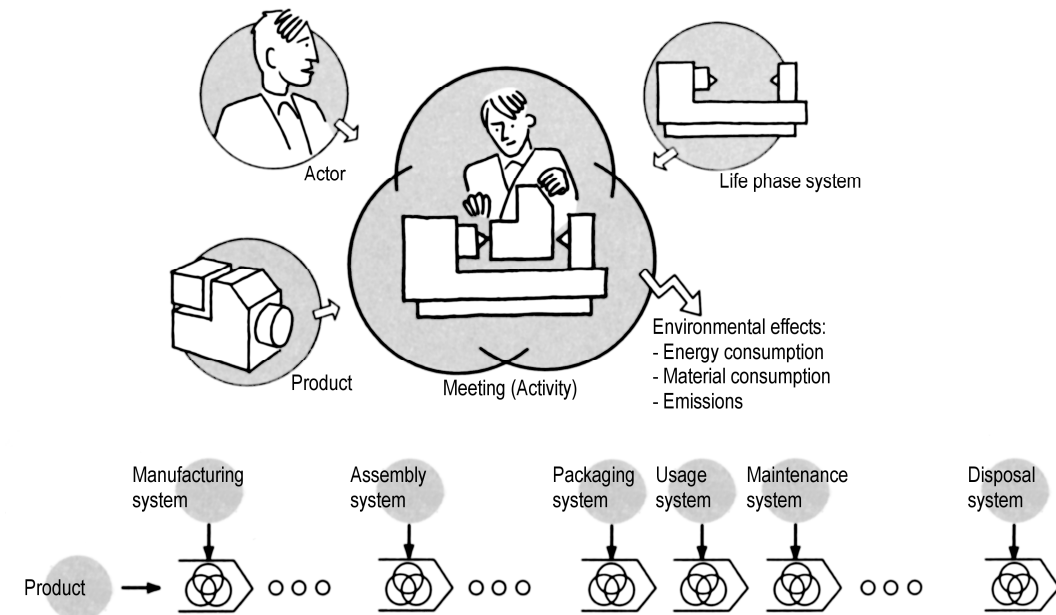


Figure 21: The meeting (activity) as key unit for the identification of product behavioural properties [Hansen 1997].

The traditional manufacturers limited influence on life phase system processes

For the traditional manufacturing company, the problem in optimising the use activity processes of customers in their individual life phase system instantiation is the lack of influence on the user's utilisation processes. Traditionally this influence is restricted to the scripting [Ingram et al. 2007] of preferred use practice, context and complementary products into the artefact itself. Whether the designed script is actually followed by users is not foreseeable and can also typically not readily be validated by the product supplier. Regarding the customers' use of complementary products, the product lives of which will consequently be meshed with the primary products life cycle (illustrated in Figure 22), the provider has traditionally had the options of restricting interfaces (e.g. toner cartridges matching specific printers) or bundling products and complementary products (e.g. PC sales including printers, software etc.).

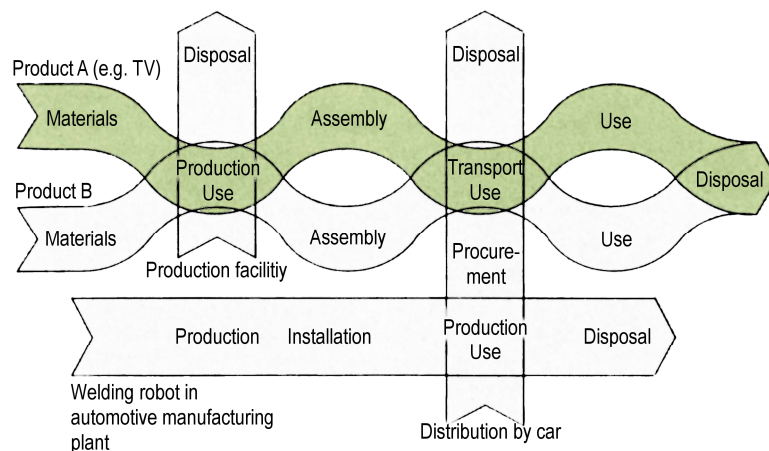


Figure 22: The meshing of several product lives throughout the life phase systems of one product [Olesen et al. 1995].

Comparing a traditional manufacturing approach with the PSS approaches described in the previous sections, PSS allows the provider to take control in setting up and managing a larger number of life phase systems throughout the product life. In the example of a documentation services PSS (delivering e.g. electronic archiving systems and standards, printing facilities, paper etc.) the provider is responsible for the delivery of paper supplies and can thus ensure the use of environmentally friendly paper to printers. Taking responsibility of life phase systems in this example allows the provider to optimise the environmental profile of the total system. It means that the product lives crossing the life phase system of use can be influenced or defined by the PSS provider, given that the provider identifies these complementary products and designs the delivery system to take responsibility for their application. Figure 22 illustrates some of the product lives participating in the life phase system of *product A* and indicates the complex meshing of product lives emerging throughout the life phase systems of any particular product.

2.8 Service modelling

As a result of the attempt to influence the service life of products and take responsibility over life phase systems, product development needs a language to describe activity processes. In the field of service and relationship marketing, concepts for the modelling of service delivery processes were developed in the 1980's. The main modelling scheme is the so-called *service-blueprinting* introduced by Shostack [1982]. In service blue-printing, as illustrated by a simple example in Figure 23, the service delivery process is divided into a number of steps, including decision points and resulting alternative process routes. The modelling scheme is focusing on processes initiated or leading to an interaction between customer and provider, and the so-called *line of visibility* indicates which process steps are transparent to the customer. The *line of visibility* is thus defining for the division between the categories of front-end and back-end processes, where back end processes are invisible to the customer, but support the delivery process.

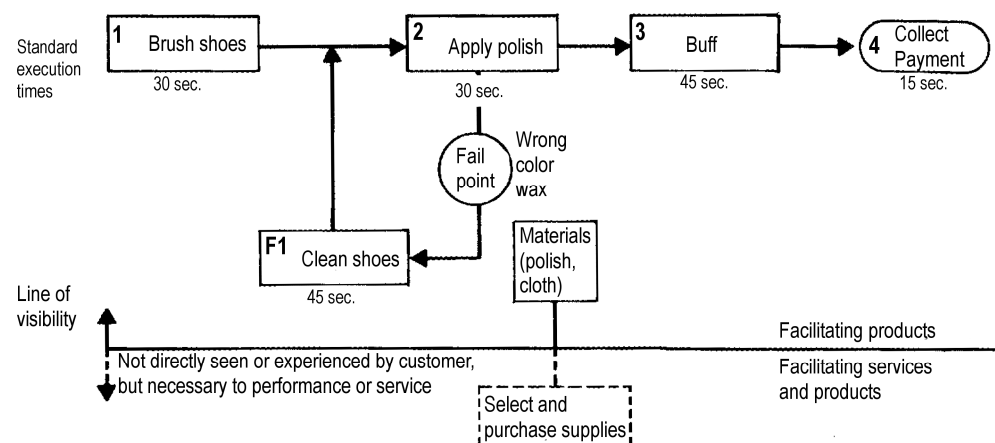


Figure 23: A simple example of service-blueprinting: The process of a shoe-shine service interaction [Shostack 1982].

Consistent quality of services identified as main issue

The main reason for introducing modelling schemes for services was the perceived problem of intangibility, inseparability, heterogeneity and perishability of services in comparison to physical products [Zeithaml et al. 1985].

These four properties of services (in comparison with product based offers) lead to the identification of three quality related problem themes. Parasuraman et al. [1985] identified that service quality is perceived to be:

- more difficult to evaluate for the customer (compared to product offers), prior to the actual service execution.
- depending on the customer's fulfilment of expectations by the actual service performance.
- influenced by the process of delivery.

Consequential to these insights, Parasuraman et al. [1985] state that it is of paramount importance to manage the customer's expectations towards the outcome of a service interaction in order to keep them in line with or marginally lower than what the service can deliver. To be able to match expectations and delivery process, the second step is to control the variation of delivery processes to the largest extend possible. The purpose of introducing service-blueprinting is therefore to make the process of service delivery visible, allow improved communication in service management, identify how service delivery quality could be improved and stabilised systematically and identify options of rationalisation of delivery processes.

2.8.1 Customer Chain

In comparison to service blue printing, which focuses on the interaction process sequence, Donaldson et al. [2006] contribute to use process modelling focusing on actor relations with the so-called *customer chain* (CC) model, which is the representation modelling scheme of the *customer value chain analysis* (CVCA) method. The CC modelling scheme is a graphical model format, in which the institutional actors involved in the activity sequence under investigation are represented as nodes in a network. Between the actors, relations of material, information and financial character are drawn, in order to create a simple visual representation of the exchange activities happening throughout the activity, as shown in Figure 24.

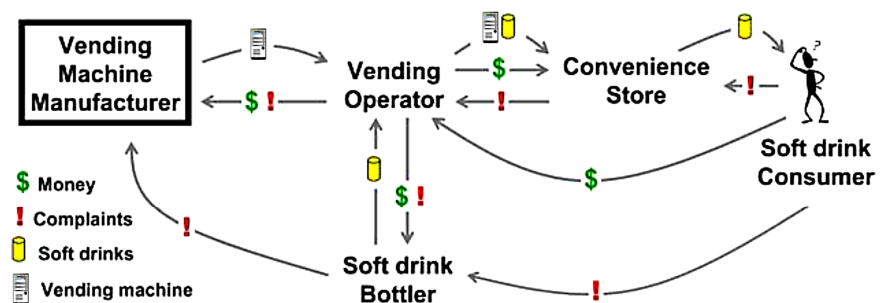


Figure 24: Example of a use phase network model using the CC modelling format [Donaldson et al. 2006].

The CVCA methods itself is designed to aid design teams of (physical) products to identify the most influential stakeholders for the product specification phase, i.e. collecting the *voice of the customer* (VOC). The contribution

of the CVCA method is mainly to identify a broader range of stakeholders compared to the sequence of immediate and end consumers downstream in the company's supply chain. In relation to the development of service-oriented business, the CVCA method assumes that the attempted business model is defined before the method is used, while in service-oriented development, the rearrangement of institutional actors can often be a main design task in itself. For the modelling and development of possible institutional network concepts, the CC model format is a relatively simple visualisation method that can be used to identify flows and relations between stakeholders in a graphical way. The CC model identifies relations between institutional actors including several processes within an undefined time domain. Compared to the service blueprinting format described above, the CC model ultimately covers the complete system of mobilised networks in relation to a predefined technology. The example network represented in Figure 24 covers at least three separate processes: the installation of the vending machine (between manufacturer, vending operator and store), the (re)filling of the vending machine by the operator and the purchasing process between consumer and vending machine. Each of the three processes could be modelled in separate service blueprints.

2.8.2 The Customer Activity Cycle

A third perspective on the graphical modelling of life phase activities is the *Customer activity cycle* (CAC) by Vandermerwe [1999], adding a further possible trajectory of modelling processes and stakeholders. In comparison with the *customer chain* model of Donaldson [2006] and the *service blueprinting* model of Shostack [1982], the CAC adds a time perspective to the model, as it models the chronological sequence of activities the chosen customer proceeds through, in order to identify possible interaction and service opportunities.

The original CAC model

The CAC model as presented by Vandermerwe [1993] is directed towards the exploration of potential customer's activities and needs, helping to inform managers on how to shape the operational profile of their company. A central point in the argumentation is the shift from the production and distribution of industrial products to the individualised provision of support in form of services, information and supplies. Vandermerwe states that the CAC model can help to enable the company to identify the necessary offerings, and to ensure that the customer is locked on to the providing company by voluntarily engaging in continuous cooperation.

The model facilitates an analysis of the chosen customer group, where the activities of the potential customer initially are divided into a pre, during and post phase in relation to the utilisation of the providing company's offerings – may these initially be physical products (as e.g. animal feed in [Vandermerwe 1993]) or any type of service (as e.g. air travel in [Vandermerwe 2000]). The model, which is described in the following paragraphs, is illustrated in Figure 25. The model implies the notion of a repetitive cycle of activities (e.g. going on business trips by air regularly), hence the circular form and the arrows indicating the sequence of activities. After the initial setup of the model, the customers' activities are identified and arranged in sequence along the circle, in order to illustrate when and where there are opportunities of influencing the customer.

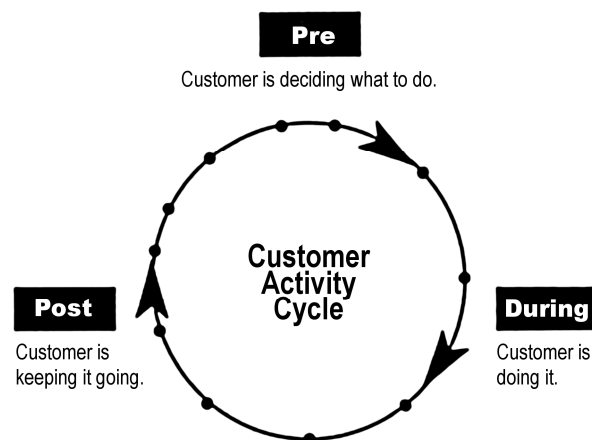


Figure 25: A conceptual model for the representation of human actors cyclic sequence of activities (Customer Activity Cycle) [Vandermerwe 2000].

The central point made by Vandermerwe is that the provider company should strive to be either directly or indirectly involved in all the identified activities – providing value by satisfying the customer's needs at that particular time. Based on the analysis of activities illustrated in the CAC model, the company can develop offerings that are appropriate and feasible to support the customer in each of the modelled activities. To complete the CAC model regarding the potential and running offerings towards customers, these are arranged around the CAC and the corresponding identified activities. Vandermerwe implies that the CAC model will help managers to create, identify and fill value gaps within their operational area, thus tying close and long lasting relationships to their customers.

The original CAC model is strong in its underpinning of the importance of customer focus – which is further supported in the papers of Vandermerwe [1993; 2000]. The model helps articulating the meetings between a central stakeholder (customer) and the provider company represented by various offerings or mediating stakeholders. In this way, the CAC gives a good understanding of the interactions between customers and company, depending on the context of the modelling either as an analysis of the current state or as a scenario of future options. Although the customer is in the centre of both the CAC model and the concern of Vandermerwe, still it seems as if the CAC is formalising the activities and needs of a single stereotyped customer. The graphical circular setup of the model might also lead to the notion that all customers have repetitive sequential patterns of activities, which depends highly on the type of market space under analysis. For the facilitation of the decision making process while conceptualising future offerings or strategies, the CAC has no formalised anchoring point within the providing company's core competency areas. Also concerning the customer there is no clear indication of the customer's primary need in the model.

Virtues and drawbacks of the original CAC

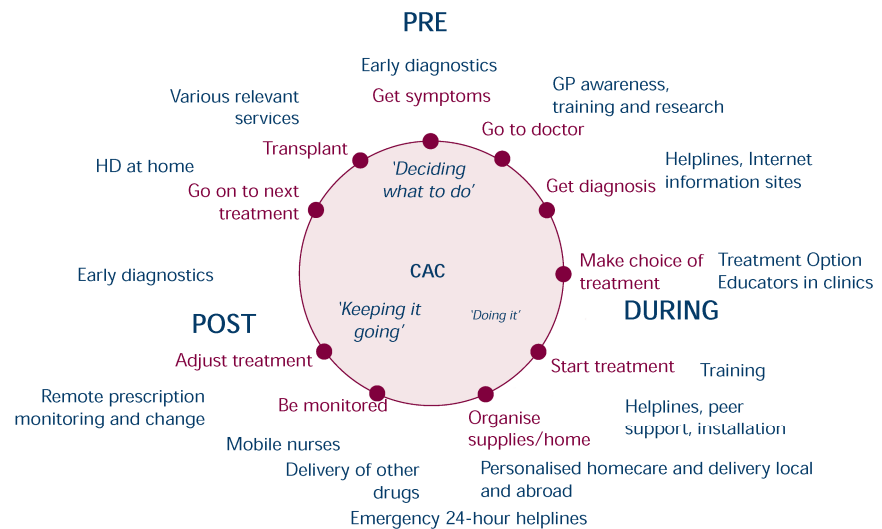


Figure 26: The completed CAC model, illustrating the offerings of a medical company to renal patients [Vandermerwe 1999].

On the feasibility of changing the companies' operations, the CAC gives no indication of what competencies are needed and how the different offerings can support one another. The offerings are not necessarily directly connected to the identified critical activities, e.g. the early awareness solution in the top of Figure 25 will only be helpful for the future renal patient if he/she actually expects a renal disease and thus checks the offered information web site. Similar criticism can be applied to many of the presented examples, and it seems like the presented granularity of the CAC analysis is often too coarse (i.e. the identified activities are not specified closely enough).

Concluding on the above, the CACs main virtue is the way in which it prompts the designer into a consideration of the sequence of activities of his customer, thereby contributing to the knowledge of the designed offerings use phase. Since the CAC originally is intended for considerations in marketing offer development, it naturally disregards issues concerning the concrete delivery mechanisms necessary within the supplying company or their network partners. Also the links, dependencies and synergies between different offering elements are not made explicit.

The CAC model of Vandermerwe has been used as a frame of reference for the development of the AMC modelling technique described in section 5.3.4

2.9 New service development

Out of the effort of stabilising and improving the quality of service delivery processes grew a development approach to services called *new service development* (NSD), inspired by equivalent *new product development* approaches in manufacturing (e.g. [Andreasen and Hein 1987]) industries and earlier contributions on the possibilities of industrialising service delivery [Levitt 1972].

Edvardsson and Olsson [1996] identify the main elements of a service concept in support of Parasuraman et al. [1985]. According to the three quality

Emerging development models aiming for quality stabilisation

The providers service *readiness* defines the customers satisfaction

themes above, they conclude that the customer's satisfaction depends on the process the customer goes through in the service delivery and the final process outcome of the delivery process. The third element in their service concept is the provider's readiness for providing the service, the so-called prerequisites for the service delivery, effectively being the provider's only channel of influencing the other two elements. A graphical representation of the service concept is reprinted in Figure 27.

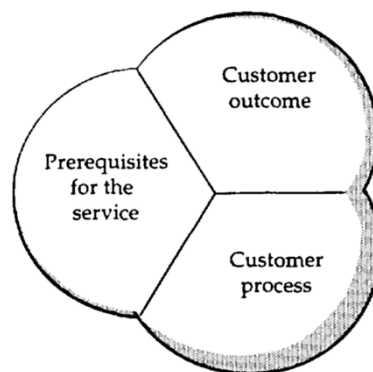


Figure 27: The concept of service consisting of three influential elements [Edvardsson 1997].

Service prerequisites are modelled in three domains

Edvardsson and Olsson [1996] also describe the key prerequisites for service delivery, consisting of the concept, process and system models, and argue that these three models are the primary design objects in new service development. The conceptual model of Edvardsson and Olsson is redrawn in Figure 28.

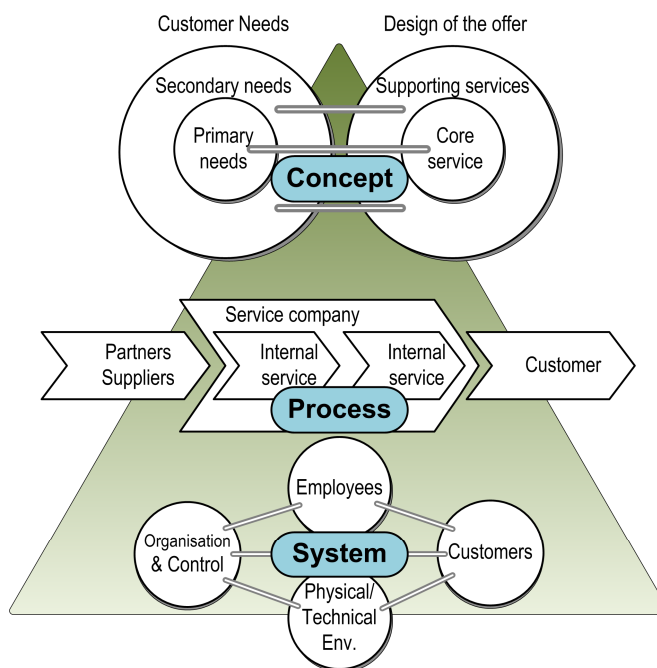


Figure 28: The three main service prerequisites to be considered and designed in NSD. Redrawn from [Edvardsson and Olsson 1996].

The *service concept* describing the need situation and the solution concept

The concept description forms the basis for developing the other domains of the service prerequisites, as it contains a description of what needs are to be fulfilled by the service offer, and how these needs are to be satisfied by the service offer. The service concept is divided into two levels, primary needs triggering the customer to utilise the service offer, secondary needs being needs arising throughout the process. Edvardsson and Olsson [1996] assume that for every emerging customer need, there must be defined a corresponding service element for to satisfy it. They also stress that many of the implicit, secondary needs actually can prove central in achieving (or failing to achieve) the customer's satisfaction. Finally the authors point to the issue of considering how the service offer can be part of a system of services (or other customer activities) that it must be aligned to, in order to fulfil the aggregate needs of the customer.

The *service system* defining the actor relationship

The system description contains the relations between customers, employees, the physical environment and the control structures governing the service delivery processes. According to Edvardsson and Olsson [Edvardsson and Olsson 1996], the control structures include the definition of responsibility distribution, administrative systems, the guidelines for interaction with customers and the creation of expectations regarding the service. Payment systems are also part of the control structures.

The *service process* describing the means of delivering the service offer

Finally, the process of delivering the service must be defined and described. Edvardsson and Olsson in this respect point to the distribution of process responsibilities between the provider, customer and possible suppliers, and the consequential necessity of understanding the customers' (individually different) processes, defining and matching the providers processes and guiding sub suppliers to aligning their processes to fit the remaining systems.

As approach to the visualisation of the process domain structures, the service-blueprinting method is assumed as the obvious choice.

Proposal of a parallel development approach to NSD

In order to develop and detail the content of the three modelling domains, Edvardsson and Olsson [1996] propose a three stranded concurrent development process, set up to develop the three prerequisite models in parallel. The process begins with the definition of the initial concept in collaboration between provider staff and lead customers to the detailed description of the three model domains. Specifically, the development process is divided into four phases, being the idea, formation, design and implementation phases [Edvardsson 1997]. The authors focus their description of the development process, on the objective of ensuring that the resulting delivery system is capable of delivering consistent delivery quality, while being resource-effective.

Service concept model in equivalent to activity models in product development

The work of Edvardsson and Olsson [1996] closely resembles the insights of Hansen [1997] and Olesen [1997] regarding the service life of product offers. The service concept in Figure 27 compares to Hansen's meeting model in Figure 21, while highlighting slightly different aspects. While Hansen emphasises the linking of the current activity with past and future life cycle phases, Edvardsson and Olsson focus their model on the individual delivery process execution and instead underline the importance of considering the individual customers approach to and processes during the service interaction. This difference elucidates one of the main differences of the research in product development compared to the equivalent efforts

in service marketing: While the product is the main actor (in the sense of [Latour 1991]) considered in product development research, the customer and his immediate experience of services is the pivotal point in service marketing.

2.10 Systematic models in design research

Prerequisites model mirroring domain models in product development

In their modelling approach towards the so-called service prerequisites Edvardsson and Olsson [1996] also mirror similar approaches in the area of engineering design [Andreasen 1980]. Comparing the two domain models, the *service concept* largely corresponds to the *transformation domain*, the *process domain* (defining the concrete interaction between provider and receiver) corresponds to the *Organ domain* and while the *system domain* seems to cover a broader range of concepts compared to the *parts domain*. The systems domain of Edvardsson and Olsson [1996] generally is heterogeneous in comparison with the other two domains, as it contains structurally different elements such as e.g. definitions of the physical environment and descriptions of information feedback mechanisms (from customer to service management) within the same modelling domain. On this theoretical level, the domain division of Edvardsson and Olsson seem to be less thoroughly defined and consistent in comparison to the corresponding models in product development. Although later reviews and case studies building on the prerequisite model [Smith et al. 2007] do not emphasise these particular inconsistencies as problematic, in this thesis it will be reconsidered whether the domain division of Edvardsson and Olsson is productive for service system development. In some respects, more recent business model concepts, such as by Chesbrough and Rosenbloom [2002] might be drawn in to reform the domain model of Edvardsson and Olsson [1996].

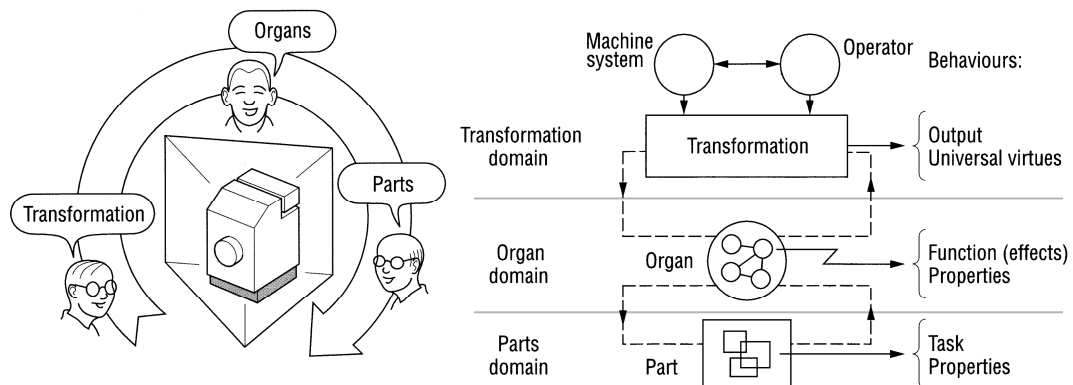


Figure 29: The three domain views on the machine system. Adapted from [Hansen and Andreasen 2002]

Development processes largely corresponding to NPD process models

Edvardsson and Olsson do not consider the linkages between their three identified domains, and consequently describe the development process as being a parallel conceptualisation and detailing of the three domains. This is in opposition to the corresponding domain theory model of Andreasen [1980], which describes the three domains central for machine system design as being three related views on the same object – the machine system. The concept is illustrated in Figure 29.

In their description of the synthesis (development) process regarding machine systems Hansen and Andreasen [2002] underline the importance of iteratively detailing and concretising concepts while shifting between domains and thus linking the parallel domain concepts into a consistent total solution concept, as illustrated in Figure 30.

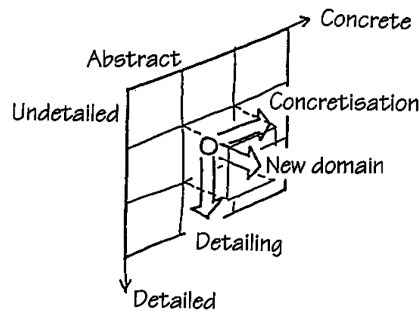


Figure 30: The synthesis steps within one domain and between domains [Hansen and Andreasen 2002].

For service development, the iterative shifting between target domains seems to yield a more productive approach compared to the parallel process presented by Edvardsson [1997].

While a number of alternative approaches to service development exist, most adhere to the general process model described in the above. Bullinger et al. [2003] largely underline the unity of contributions within service development, although they point to the *prototyping* approach illustrated in Figure 15, which they evaluate suitable for some specific service development contexts.

Johne and Storey [1998] identify a number of differing methods depending on more specific objectives of service development projects, such as differences between *offer* and *business* development projects, but generally agree to the phase divided process models of Edvardsson [1997].

A different approach applicable for the description of activity processes and service interactions is the *transformation system model* first presented by Hubka [1973].

A systematic model of the generic use process

The *Theory of Technical Systems* of Hubka and Eder [1988] is a theory describing technical systems and their application in transformational processes, originating from within the paradigm of a *General Systems Theory* (GST) [Bertalanffy 1951]. Hubka and Eder acknowledged the convergence of machine systems into integrate systems of mechatronic character and thus argue for the necessity of a common theory for all technical systems. Nevertheless their book and later works as e.g. [Hubka and Eder 1996] draws examples predominantly from the domain of mechanical machinery and clearly reveals the origin of the TTS from Hubkas work of creating a systematic model covering machine systems [Hubka 1973].

The TTS fundamental model is the *Transformation System model* (TrS) that formally describes a human initiated process as an activity system, including operand inputs and outputs, operators and system borders. Figure 31 shows the constituents of the TrS. The initiating need of transforming the operand from its current state Od^I to a new state Od^P is realised through a transformation process TrP that is characterised by application of a tech-

nology T_g . The transformation is executed by human operators HuS using technical systems TS to perform the transformation. The execution operators are supported by information systems IS and the process is controlled and evaluated using a management and goal system $M\&GS$. All operators influence the process by the exchange of material M , information I and energy E between process and operators. The transformation is taking place within an environment Env of time and space, also exchanging material, information and energy with the system.

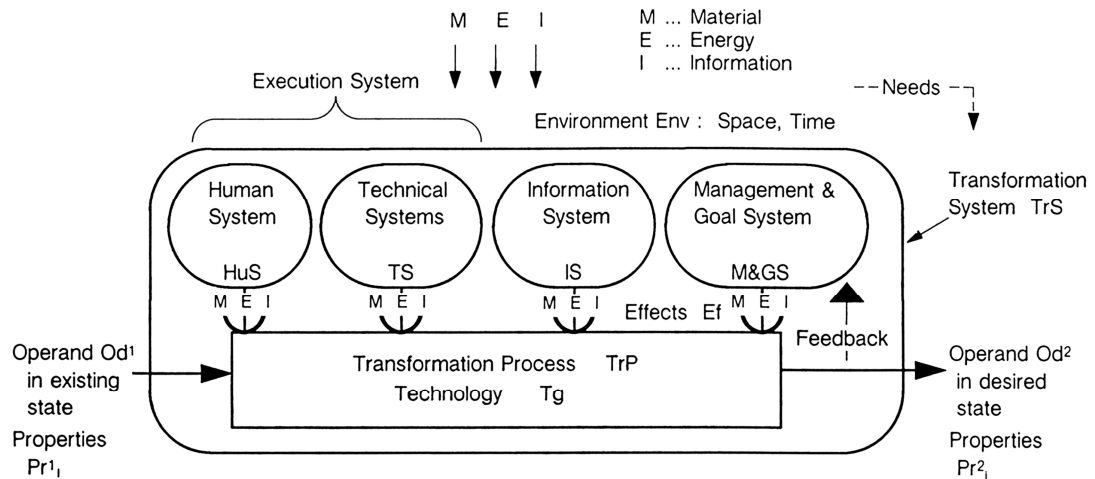


Figure 31: The transformation system model of Hubka and Eder [1988].

The TrS model is strong in its explicit division between the transformation taking place and the means of executing the transformation. The categorisation of the operators into human, technical, information and management related means is interesting for the application to PSS, as it prompts the designer using the model in a design process to consider the different options of supporting the transformational process through inputs within the four categories.

Compared to the service-blueprinting scheme, the TrS model explicitly defines the difference between operators, operands and the transformational process and therefore more clearly defines the elements of the life phase system (cp Figure 21) modelled. As the TrS model strictly adheres to the hierarchical rules of systematic modelling, the scope of transformations can be scaled according to the chosen granularity of modelling, e.g. to black box all activities of one life phase, and still retain an unchanged structural composition. While this structural consistency fit well to the intentions of complete modelling of technical systems in accordance with the ideal of the GST [Bertalanffy 1951], in application to the concrete modelling of life phase activities, a number of issues arise.

The difficulty of applying the TrS modelling scheme is to set the frame of what is considered part of the actual transformation process and what is to be considered the environmental context of the systems process execution. An example is the gathering of experience by the human operator executing a maintenance process, which will change the operator's approach to subsequent similar processes and thereby effectively make him an operand in the process. This simple thought example underlines the challenges of defining suitable time and scope boundaries for the modelling of delivery

The TrS model as frame for the modelling of life phase activities

Application of TrS within a SSM mindset

processes. Within the scope of a single process execution, the categorisation between operands and operators is practical, for long term modelling (e.g. the service life of a technical system) the distinction between operands and operators, and even between types of operators becomes blurred.

In literature, the TrS model has been applied to the structuring of design processes [Eder 2001], but it seems that there is a possibility of using the TrS scheme for concrete design modelling purposes, if the model is transferred from the framework of GST to a more application oriented approach similar to the *soft systems methodology* (SSM) proposed by Checkland [1981]. Pidd [2003] describes how the SSM can be used to analyse and design solutions to management problems in organisations.

The methodology principle is illustrated in Figure 32, in which the problem solving process begins with the identification of the problem solution. From there the methodology proceeds to the analysis of the situation and construction of a partial system describing the relevant parts of the organisation. In the transition from the explicit description of the situation to the modelling of the mechanisms causing the current situation, the translation from the real-world situation to the system based abstraction is completed. In step 4, the modelled situation (3) is altered through the synthesis of possible model changes, which is followed by the comparison of modelled concept and current reality. Finally, change actions are decided and taken based on the conclusions of the comparison and the improvement cycle is reiterated for further improvement. Throughout the process, the relations of the actors driving the change process to the organisation being subjected to changes must be reflected upon, in order to ensure that changes are improving the general organisational state. This last issue is illustrated by the reflection loop indicated outside of the system borders of the iteratively changing organisation.

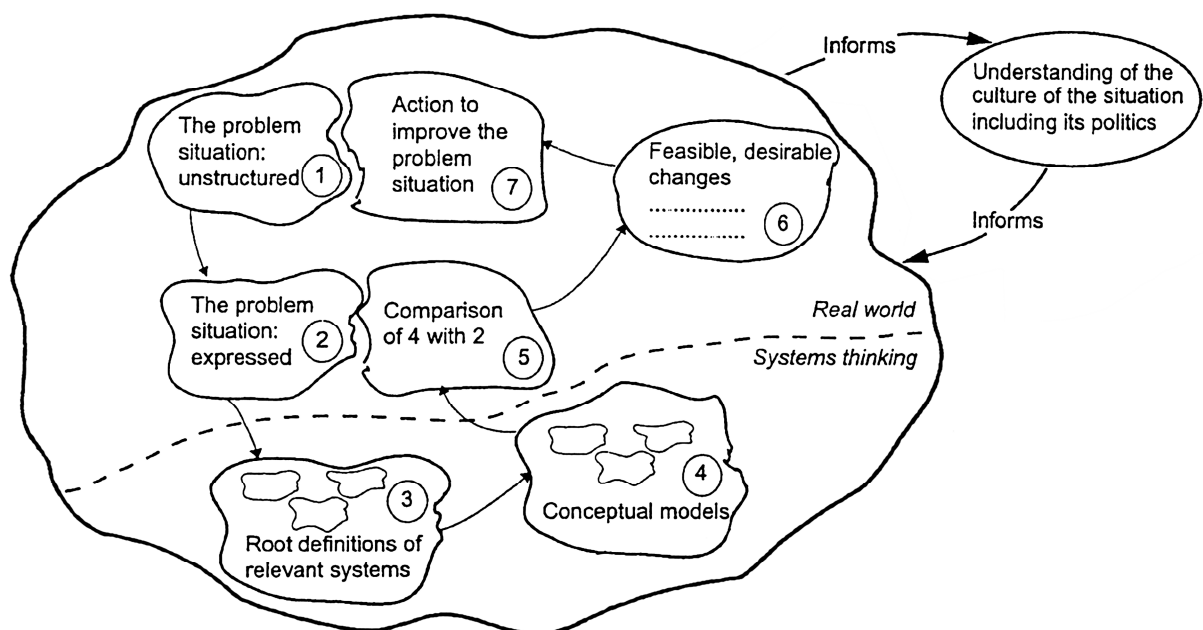


Figure 32: The principle of Soft Systems Methodology. Adapted from [Pidd 2003].

While the SSM in general is a method to solve managerial problems in organisations, the mindset governing the system modelling steps can be transferred to the modelling of product life activities. The key difference from the GST approach to systems modelling is the premise that the system model is generated only for the purpose of aiding a change process. This implies that the system model per se is acknowledged to be incomplete and focused on particular entities and relations of the real world, without the claim to be an all-inclusive description of reality.

In conclusion, the merging of the TrS modelling scheme with the mindset governing SSM might prove to be a feasible method to model relevant service life activities, i.e. selecting specific situations and activities relevant for PSS design and development, leaving out irrelevant other phases and activities. Obviously, the consequence of this adaption must be that the designer reflects upon his choices throughout the design process.

2.11 Service Engineering as an approach to PSS design

Taking responsibility for life phase systems

While the RQP and inverse manufacturing concepts require the supplying company to actively design and implement systems for handling the reconfiguration and redistribution of the RQP modules, they do not envision the manufacturer to be actively involved in the actual use processes of the RQP's product life phases. These are not mentioned and assumed to be governed by the products user and related actors alone. Tomiyama [2001] takes the final step for the manufacturer to take responsibility of the use life phases by introducing the concept of *service engineering*. Service engineering aims for the application of a systematic design methodology (equivalent to e.g. the engineering design methodology by Pahl and Beitz [1996]) to the design of the actual service delivery process, i.e. the activities taking place in the interaction between a customer and the servicing entity (regardless of it being human or technology).

Modelling the product as the vehicle of delivered service

To support the development of services through service engineering, Tomiyama builds a model for the conceptual representation of the servicing activity.

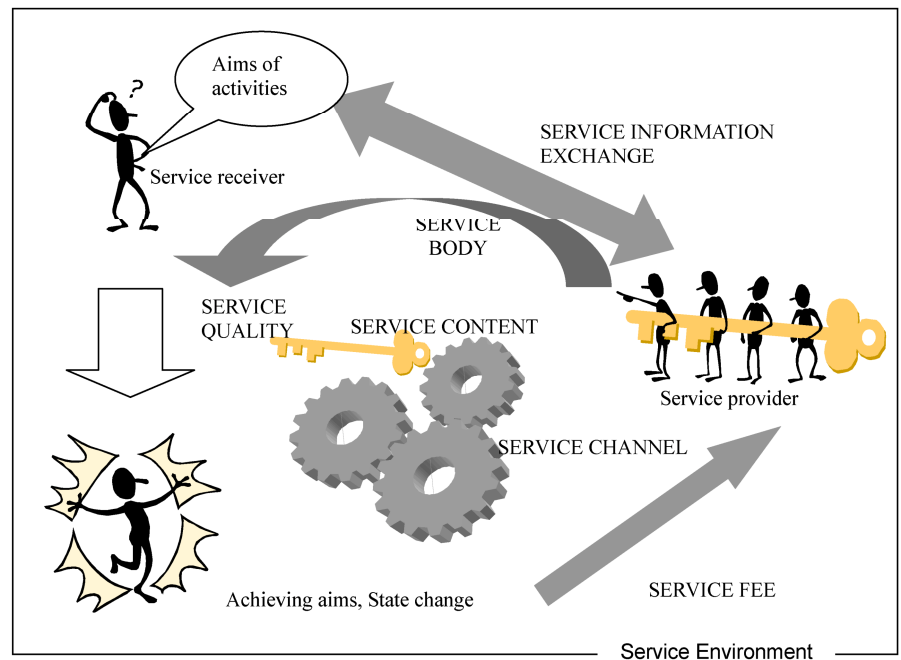


Figure 33: The service model of Tomiyama [2005].

Figure 33 illustrates the *service model* of Tomiyama. It defines service to be an activity in which a provider changes the state of a receiver by delivering *service content* using a *service channel*. Content and channel constitute the *service body*, and the satisfaction of the receiver defines the *service quality*. The service activity is initiated to support the receiver in achieving his aims and entails him to pay the provider a *service fee*.

E.g. an airline company is the provider of air travel, by which it changes the position (i.e. the state) of the traveller (i.e. receiver) through the provision of flights (i.e. content) performed by aircraft, airport, stewards etc. which constitute the channel. The flight enables the receiver in achieving his goal of travelling, in the return of which he pays the provider for the flight (i.e. the service fee). The traveller's perception of booking procedures, check in, baggage handling, airport offers, seating and in-flight attendance will be defining for his individual perception of the flight quality.

While the above example represents the deliveries of a traditional service company (i.e. an airline), the same modelling view can be applied to product related services like e.g. an authorised mechanics yearly maintenance check of a car, or the provision of well a tempered environment by a radiator thermostat and heater, i.e. a technology product's service.

Importantly, the individual receiver's perception of the service activity's utility and fit to his aims and needs defines the value of the received service. Thus the service provider negotiates a *value proposition* with the receiver, which is then evaluated according to the actual execution of the service. The service model represents an approach very different from the one taken by e.g. Olesen [1992]. While Olesen is attempting to improve product performance by anticipating and preparing its fit to changing product life phases, Tomiyama focuses strictly on a single product life phase and its activities, while disregarding the products path crossing that life phase ac-

Service model is applicable to product's service delivery

Service model as foundation for the development of data models

tivity. Comparing the models in Figure 20 and Figure 33, reveals how the dispositional score in a product centric manner is aligned with the chronological course of the products life, while the service model is a snapshot of the utilisation activity.

As stated earlier, the service model was initially developed in order to support the development of services in a structured way. Based on the service model of Tomiyama, research has been conducted aiming for the development of a methodology for service engineering [Shimomura et al. 2003], supported by IT in the form of a *ServiceCAD system* [Arai and Shimomura 2004]. The Service Engineering methodology consists of a structured process model, which through the application of five main steps guides the designer in modelling the concept of a service design [Sakao and Shimomura 2007]. The applied modelling scheme, which is stabilised into a data model through the prototype service computer aided design (CAD) system *Service Explorer*, is an expanded version of the service model illustrated in Figure 33. The modelling scheme consists of four sub models with their separate focal content. The relations of three of the sub models are illustrated in Figure 34.

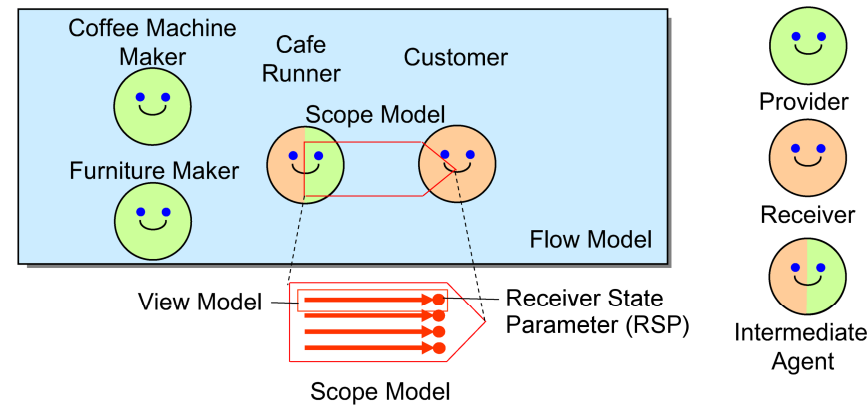


Figure 34: Overview model representing the relations between flow, scope and view models used in service CAD prototype software. Example showing a café service. [Sakao and Shimomura 2007].

The flow model

The four models are the flow, view, scope and scenario models (of which the scenario model is not represented in Figure 34).

The flow model represents the network of agents involved in the delivery of service to the receiver. The model propagates backwards from the interaction between the service receiver (SR) and the immediate service provider (SP). The immediate service provider will in many cases (e.g. in Figure 34) be an intermediate agent of primary institutional provider(s), although not necessarily depending on them.

In the example in the figure, the café owner is an intermediate agent seen from the viewpoint of the manufacturers of café furniture and coffee machines. If the scope of the flow model was changed, there might be constructed a model where the owner would be the institutional provider, while a waiter might be introduced as a further intermediate towards the café customer. This mental experiment shows one important property of service actor network modelling; it is important to define both scope and granularity of the model.

The scope is defined through consideration of the service delivery *ownership* as the primary (provider) agent will seek to transfer value through the intermediate agents on to the final receiver. The granularity of modelling the actor network implies how many intermediate agents will be identified, thereby producing a richer (but also more complex) picture of how the transfer of value from primary providers to the final receivers is set up.

Another important observation in analysing the flow model is the consideration of the time dimension. In the example in Figure 34, there is an obvious time lag between the activities of the furniture and coffee machine manufacturers (furnishing and equipping the café) and the servicing interaction between the café owner and the customer. Even if the primary actors are active participants in operating the café (e.g. by cleaning or coffee supply services) the activities of the different actors would still be asynchronous.

Referring back to the product centric score model of Figure 20, the flow model in the example links actor networks of distinctly different life phases. This on the one hand prompts the designer to consider how the manufacturer actually can prepare to support the scope of delivery attempted in the servicing activity, but also if intermediate actors in the delivery chain are considered sufficiently. On the other hand, there will probably only exist weak connections between the primary provider and the intermediate actor involved in the concrete interaction with the service receiver.

The Scope model

The scope model describes the service delivery, the service content delivered through the service channel between provider and receiver. In Figure 34, only the scope of delivery between café owner and customer is indicated, while in effect there should be defined delivery scopes for all provider-receiver relationships (such as e.g. between coffee machine maker and customer). In the service engineering data model, the service delivery is represented by a number of separate view models, each describing the influence on the involved actors, represented by the alteration of a so-called *receiver state parameter* (RSP).

The scope model is thereby describing how the interaction between a provider and a receiver is supposed to imply changes on the receiver's state in a quantified form. Compared to engineering design modelling approaches such as Pahl and Beitz' [1996], the scope model represents the functional decomposition of the servicing activity into a number of parallel delivery function hierarchies, each contributing to the alteration of one identified RSP.

The View model

Each of the view models finally describes what concretely influences the particular RSP's value. In the café example of Figure 34, the provision of a table and a chair to the customer would influence the RSP of comfortable seating, while the waiter's delivery of a menu might influence the customers' sense of feeling welcome and well attended. In the data modelling scheme of service engineering, the influence of service activities on RSP's is codified through transition graph type models, which are representing the influence of concrete physical products and activities on the identified RSP.

By modelling of the conceptual service activity using the flow, scope and view model, the main properties of the service activity are defined or de-

scribed. Referring back to the fundamental service model in Figure 33, the three sub models cover all the generic aspects of the service delivery activity, i.e. the active actor network, the scope of deliveries between every actor pairing and the utility objectives aimed for with those delivery functionalities. In recognition of the uniqueness of the individual receivers' satisfaction and perception of service quality, the scenario model describes both the general and the personalised total state change impact of the designed service on the receiver. The scenario model thus represents the translation of the generic delivery functionalities described in the other three models into a personalised utility impact on the service receiver.

The scenario model

The scenario model is a data model representation of the receivers' aims and needs. It consists of a general model describing a set of identified (human receiver) states (e.g. influx of heat or feeling of wellbeing) which are linked to each other through defined parameter relationships (e.g. influx of heat influences the feeling of wellbeing) and can be graphically represented by a transition graph model. The states in the transition graph model are called *receiver state parameters* (RSP) as they accumulatively represent the state of the service receiver. The RSPs are divided into the classes of external and internal RSPs, where the former describe the physical state while the latter is describing the internal or mental receiver state, usually influenced by changes in the external states.

The stated generic RSP's can be prioritised and evaluated regarding the specific needs and preferences of stereotyped users, through the application of a specified value matrix, in effect a data model representation of the persona concept introduced by Cooper [1999]. Through this prioritisation of the parameters the complex general transition graph is reduced to a resulting satisfaction value for every constructed persona profile, thereby allowing a model based calculative evaluation of a service interaction's suitability regarding different customer groups.

Applying the models of service engineering in service design processes

Returning to the tasks of designing services, the models above are envisioned to support the service designer. While in the process of conceptualising a service interaction, the evolving service CAD model is to support the designers reasoning, just as mechanical or electronic CAD models support engineering and hardware designers in their design processes. Similar to existing CAD models, the service CAD models also aim for a gradual and parallel documentation of the evolving service concept.

Sakao and Shimomura [2007] divide the proposed design process into the following process stages, which are assumed to be executed iteratively. An outer iteration loop between stage 2 and 5 and an inner iteration loop between stage 3 and 4 allow the evolvement of the service concept up to a final design solution.

1. Making a preliminary flow model (identifying agents)
2. Describing the target receiver (defining the customer segment)
3. Describing the value (defining RSPs to be altered)
4. Generating realisation structures (defining the service content and channel)
5. Adapting the flow model to the generated realisation structures (evaluating alternative solution models)

The five stages process is supposed to be closely supported by the evolving data models in the CAD software. The different modelled entities, e.g.

agents, scenario models and transition graphs are envisioned to be drawn from a growing database shared between all service-CAD users. The growing pool of modelled services is envisioned to relieve the designer from modelling work through the reapplication of existing model elements into new solution concepts. Finally the service-CAD system is to support the comparison of proposed and existing service delivery concepts through a graphical representation interface [Shimomura 2007].

On a more methodological level, other researchers also promote the idea of using the knowledge of existing service concepts to inspire service designers in the design of new service solutions [Tomiyaama 2005].

The approach of a CAD based service design method seems convincing considering the success of other CAD application areas. Nevertheless there seem still to be shortcomings in the approach in relation to applying the methodology in an industrial context.

High level of translational reduction
through data modelling

The main potential problem lies in the extreme translational reduction currently applied, in order to codify the preferences of selected personas into the scenario data model. The persona concept of Cooper [1999] invokes the imagination and associative capabilities of the human designer in order to let him evaluate a certain solution concept's relevance for the imaginative user profile. The current service engineering approach instead attempts to let the designer first translate the persona's preferences to a (relatively small) number of parameters and then relate these parameters to each other in a node network, only to allow the computer to create an algorithmic prioritisation and evaluation of different service delivery models. While this translation allows a standardised evaluation of alternatives and yields a clear quantitative result i.e. representing repeatability and precision if applied with the same parameter data, the approach is sensitive to changes in the parameter data and thus might not yet yield a high accuracy in the comparison between different parameter data sets of the same persona profile.

Stability issues of data models

Another issue is the rigour necessary in the modelling of different aspects of the actor network and the delivery scope while at the same time modelling on an abstract level of functional mechanisms (as opposed to the physical entities modelled in traditional CAD systems). If compared to e.g. engineering design students widely differing functional structuring models seen in university course assignments on simple mechanical products, the establishment of stable functional decomposition of servicing processes is a challenge for the service designer using the service CAD tools.

Regardless of these objections to the current applicability of the concrete prototype tools, the service model and its expansion into the data models used in the service engineering approach reveal important aspects to be considered in the development of service systems. The main of these are:

- Defining the actors influencing and taking part in the service interaction.
- The individual evaluation of service quality and satisfaction by the service receiver unique for every service interaction.
- The relations between every direct and mediated pair of actors present in the delivery network.

2.12 Actor Networks and service oriented business

Regarding the stability of data models, Latour [1999] contributes through the exploration of how local and individual reality is *transformed* through *translational reduction* into generally applicable phenomena, which in turn have lost their individual uniqueness. This means that through the computational *reduction* of the real human user, let alone the imagined persona, into a matrix of key properties, it becomes increasingly difficult to retain a reversible process and actually meet the expectations of the future customer.

Latour [1991] also explores the displacement and transformation of relations between distant human actors mediated through artefacts, the so-called non-human actants. Latour [1991] describes how technology is loaded with intention by its designer, an intention that the technological artefact carries in terms of the features inscribed into it. Latour uses the example of a hotel key that is fitted with a lead in order to physically remind the hotel guests to leave the key in the hotel. The key *displaces* the message of the hotel owner please to leave the key behind when leaving. This first argument establishes that things carry and communicate meaning between human actors; they in fact turn into actors themselves. Latour argues that the key in effect *transforms* the meaning inscribed into it, as the inscription of the designer will be read slightly differently by users.

Ingram et al. [2007] build further on these contributions and define six phases in the process of creating use practices for new objects (which might be of artefact or process nature) by users within their so-called field of practice: acquisition, scripting, approbation, assembly, normalisation and practice. *Acquisition* covers the reasons for individual customer to use a certain object but covers also the hurdles of overcoming existing practices, which can be an important factor regarding the shift from product- to service-oriented business. *Scripting* represents the influence the new object has on the user, while *appropriation* describes the user's adaption of the technology to his needs. *Assembly* labels the way in which objects are related to other objects and activities of the user, while *normalisation* and *practice* represent how the initially novel object is turned into an object of normal use, following a general *practice* of use.

Ingram et al. [2007] thus underline the important changes the product or service undergoes in the period of being disseminated from novelty to normality, and that the complete anticipation of use practice is difficult, just as the *acquisition* of products and services is highly depending on how the future users can relate to the offered service in comparison with the existing alternatives.

2.12.1 The nature of product and services

Regarding the *acquisition* of products and services, Callon et al. [2002] contribute with an explanation regarding the tradability and general properties of both products and services. Callon et al. introduce the concept of *goods* as being a stabilised image of product or service, a mental device enabling the trading of products and services in the market. Callon et al. [2002] describe, building their description on the example of physical products, how the product in reality is changing throughout its life cycle. An example for this could be the progression of a car from the manufacturing line, through

the dealer's showroom, being sold to a customer, travelling thousands of kilometres before being sold again on the second hand market. The first owner will stabilise the car's unique and changing condition into a set of properties (mileage, standard etc.) which makes the unique car comparable to other cars offered on the market. A comparable process makes service offers comparable and tradable, just like physical objects.

This acknowledgement of products being just as heterogenic as services were identified being in many contributions within marketing literature (e.g. [Zeithaml et al. 1985]), is further explored by Araujo and Spring [2006] who discuss different notions of the apparent division between product and service delivery.

They build on the contribution of Hill [1977] that investigated the options of accounting the service economy's fraction of national economy. In his work, he identifies that the institutional relationship of provider, supplier and customer is the decisive categorisation factor to distinguish between product and service business. It means that a paint job can be considered a service, if a painter is paid to execute it, or alternatively a product if the building's owner is doing the job himself. The apparent distinctions, predominantly referring to the institutional relations between provider and receiver are illustrated in Figure 35.

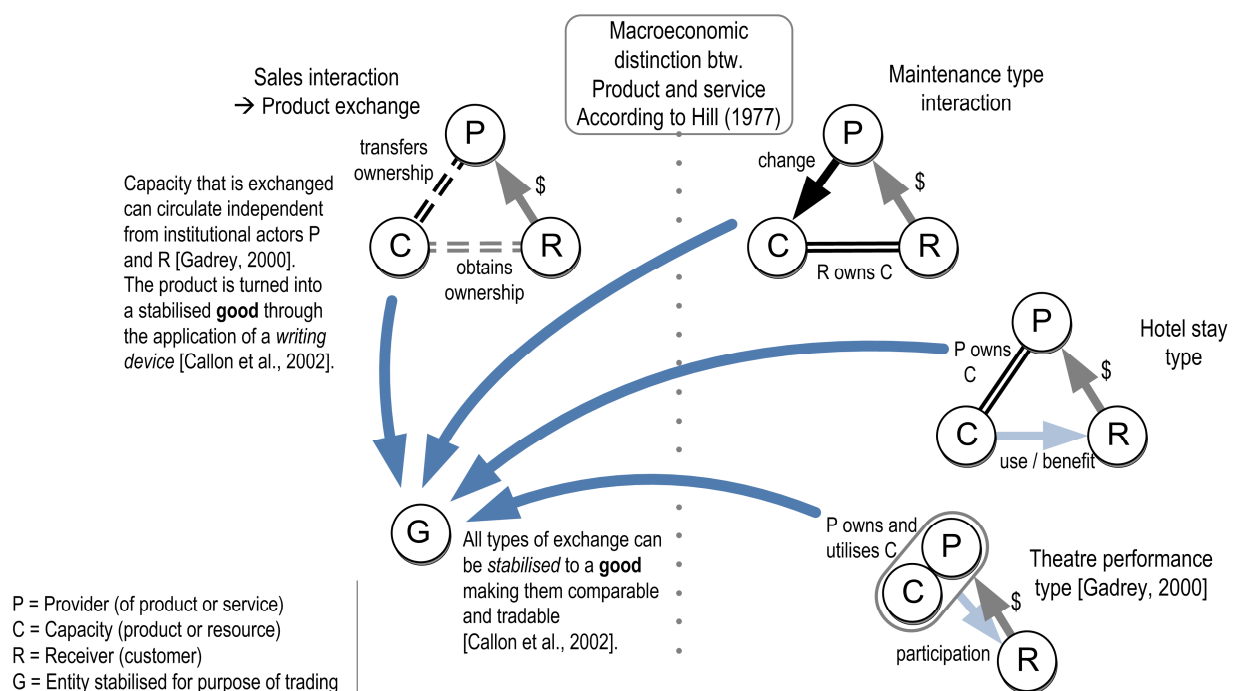


Figure 35: Four different types of economic interaction. Referring to [Hill 1977; Gadrey 2000; Callon et al. 2002].

In effect, Figure 35 underlines how the difference between product and service in the exchange economy domain is primarily a question of ownership of capacity and definition of tradable objects. A car owned by its driver has presumably been acquired by its owner through a product exchange (i.e. the car is regarded as product). If it was rented or leased by the driver, the car's provision of transport is to be regarded as service.

2.12.2 The two competing notions of service

Returning back to the argumentation of Callon et al. [2002] the product is regarded as a process, a trajectory in time that is altered by and alters its surroundings. The product throughout this lifelong process delivers utility to its users, a utility that is regarded a *service delivery* in the domain of design research [Tomiyaama 2001]. The service life activities, described in section 2.5, are actually instances of *service delivery* by the product to the actors involved in the use activity. Consequently the concept of service is distinctly differently defined within the domain of design compared to the literature in economics and most contributions within marketing. While the two different concepts of service obviously lead to confusion, both of them are important for research in the field of PSS.

The service categorisation of Hill [1977] (cp. Figure 35) explains the relationship between provider and receiver of services (or products). The receiver of a taxi ride for instance, is not responsible for the roadworthiness of the vehicle, which he is when driving his own car. The service delivery concept of Tomiyama [2001] (cp. Figure 33) on the other hand describes what the receiver is expected to gain from his participation in the service process, and the service model categorises what resources are activated to deliver the service. Taking the same example as above, the taxi passenger and the car owner receive the same basic technical service – transport from point A to B. Despite this, the taxi ride obviously delivers other service elements like e.g. the luxury of having a chauffeur, while the person driving himself will perceive feelings of control and pride of ownership. The example is illustrated in Figure 36. The concept of service delivery is related to the *functional unit* concept, which is used in life cycle assessment methodologies to define a common denominator for the comparison of environmental effects of different products [McAloone 2001; Bey and McAloone 2006].

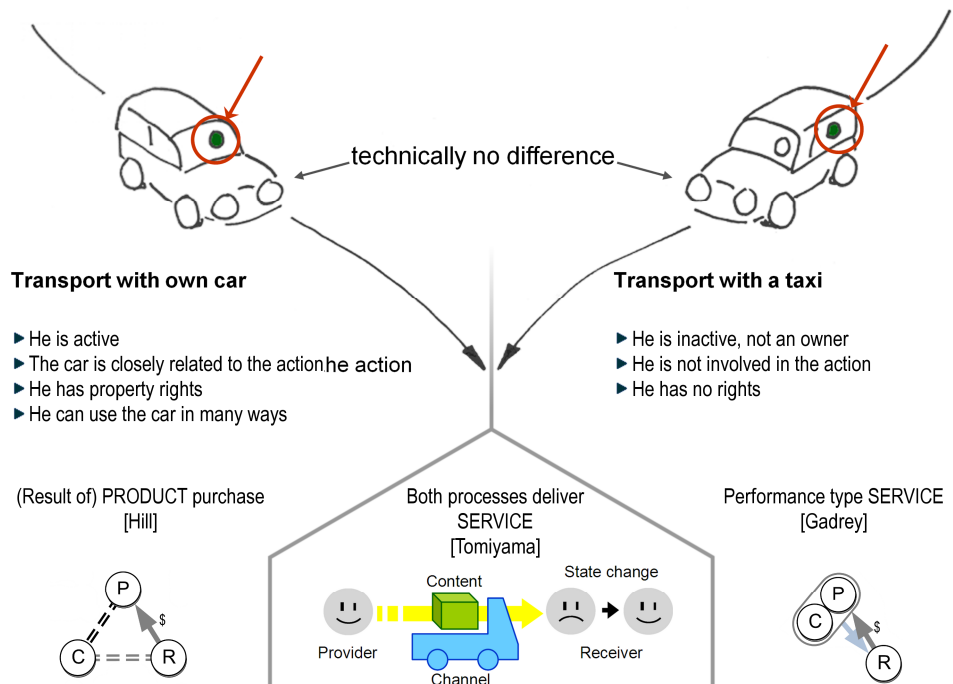


Figure 36: The two different concepts of service and service delivery. Based on contributions in [Hill 1977; Gadrey 2000; Tomiyama 2001].

2.12.3 Value creation

In his delivery model, Tomiyama introduces an important aspect of the service delivery process in describing how the service receiver evaluates the service body's quality according to his aims and subsequently, based on that perceived value, evaluates his satisfaction with the provided service. This evaluation includes both an absolute evaluation of whether the receiver's objectives were reached and a relative evaluation regarding the balance of cost and benefits regarding the received service.

In the design and marketing literature, the creation of value for the user has traditionally been linked to the fulfilment of expectations set prior to the acquisition of a product and the perception of quality and functionality in its use. Most researchers refer to Kano (e.g. [Kano et al. 1984]) for the first model describing the elements of quality perception and subsequent user satisfaction.

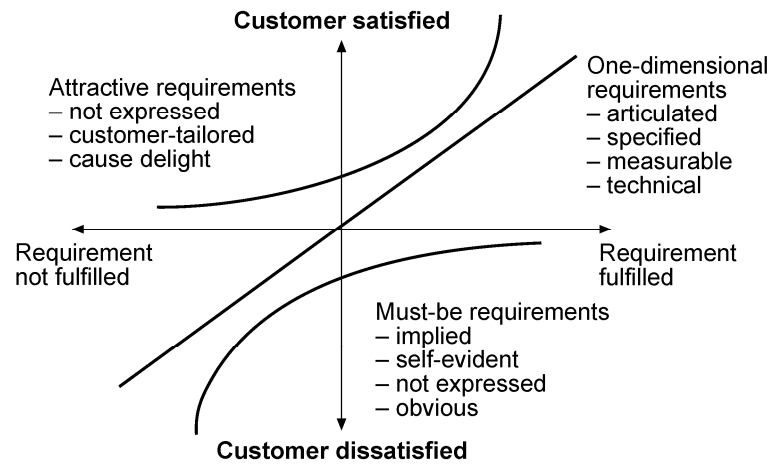


Figure 37: A graphical representation of Kano's customer satisfaction model, Reprinted from [Matzler et al. 1996].

Kano's satisfaction model derives the satisfaction of customers with a service or product from three requirement categories: the unexpressed *must-be* requirements, which must be fulfilled to render the offer usable for its use; the articulated *one-dimensional* requirements, which are explicitly asked for by customers and the *attractive* requirements, which can differentiate the offer from other alternatives in the market.

The so-called Kano quality model implies that while *attractive qualities* of the offer cause delight effects and thus are important for successful offers (regardless of them being products or service-interactions), their absence will not influence the customers evaluation of the offers need fulfilment negatively. This implication has since been debated, and Mørup [1993] notes that features which were specifically designed as *delight factors* into the product will uncover latent needs in the customer. If these needs are not subsequently fulfilled by the product, the *delight factor* might cause dissatisfaction due to poor performance. While the so-called Kano-quality model creates a productive requirement categorisation that can be used e.g. in the prioritisation of offer features or functionality in design and development, the three quality categories must be seen in relation to the individual customers context.

Ingram et al. [2007] describe a number of personal contextual factors influencing the perceived satisfaction of consumers, which are not directly related to functionality or utility. They include social comparison, creation of self-identity, mental stimulation and novelty, matching and specialisation. All of them imply that the perceived value of products and experiences declines with time, driving consumers to substitute their old products and service arrangements with new ones.

3 Introducing service oriented product development

As the result of a project exploring the product development issues of Danish industry after the general adoption of *integrated product development* (iPD) approaches [Andreasen and Hein 1987], Robotham and McAloone [2000] suggested the necessity of considering all life phase requirements and their influence on each other in the early stages of product development. The approach is called product life thinking and is building on the principles of the theory of dispositions [Olesen 1992]. The concept of product life thinking refers to a development approach where not only the primary use functionality of the product is in focus, but where the all anticipated life phases of the product are analysed and contribute to the list of use property objectives and consequently the specification of requirements for the products design and development. The expansion of the product concept is illustrated in Figure 38. The arrow indicates the primary utilisation activity, while the surrounding emphasised area indicates the so-called service life time span. According to McAloone and Andreasen [2004] the entire service life period's properties must be considered in product development.

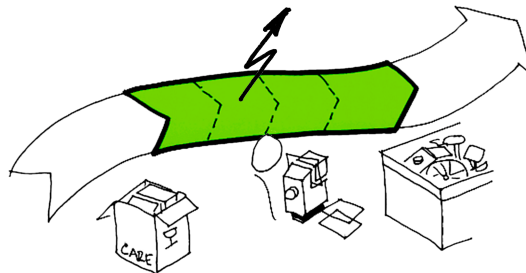


Figure 38: Expansion of the product concept [McAloone and Andreasen 2004].

Exploring the concept of product life thinking further, McAloone and Andreasen [2002] identify how the approach could be utilised to expand the design object of product development to include the life phase activities of the product in its context and ultimately aim for the development of product/service-systems.

Linking back to Olesens score model (in Figure 20), the development of PSS requires the identification of central service life phases and the subsequent development of optimised delivery processes for them. As these processes are executed in the interaction of product, actors and the life phase system (cp. Figure 21), PSS requires the consideration of product performance, actor responsibilities and properties of the process context, i.e. the life phase system design. If the development efforts within this approach remain focused on the definition of the product itself, the product could be labelled to be *designed for service life*. If the development efforts include the definition of delivery systems ensuring a specific setup of the life phase system or prepare for a controlled support of the actor (up to and including the possible transfer of activity execution responsibility to provider employed actors) the resulting solution concept can be labelled a *product service system*.

If the manufacturer ultimately takes over the operational responsibility for the utilisation activities of the product, the *product delivery* has been substituted by a *service delivery*.

3.1 New channels of service delivery

Compared to the traditional modelling of utilisation processes, where the product is the only channel the manufacturer has available to influence the user's use process, combining products with supporting services opens additional channels of delivery to the providing company. The provider of product services becomes an active part of the utilisation process, and can actively influence process execution and properties. This active involvement in the utilisation process is a prominent property of product service delivery, and Matzen et al. [2005] proposed that a *parallel transformation system* model (PTrS) can be used to model it and yield productive insights for the development of PSS. The PTrS is illustrated in Figure 39. Although the transformation system model of Hubka and Eder [1988], which was used as a underlying basis for the PTrS, includes the identification of governing *goal systems* as part of the management operators influence, the model does not clearly (and graphically) indicate the division of responsibility between the actors governing the process execution. To underline the responsibility division between customer and service provider, the original TrS model (cp. Figure 31) is divided into two parallel transformations, representing the division of responsibility between the customer (user) and the supplier part of the activity.

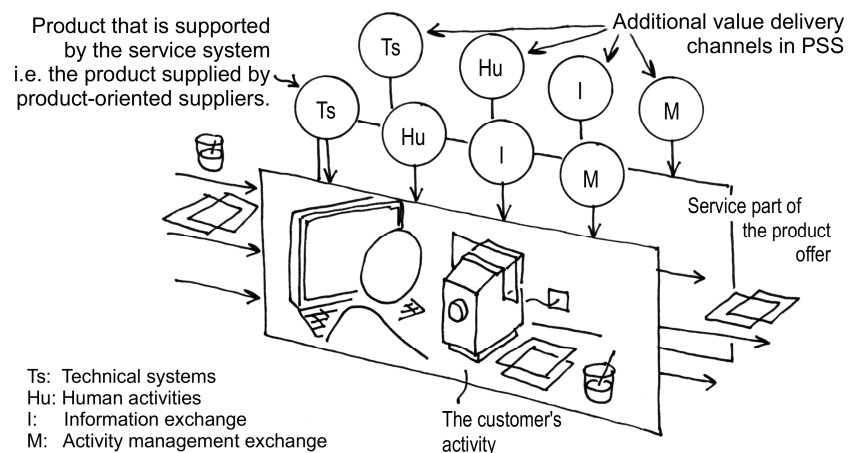


Figure 39: The adapted transformation system model, identifying the service provider's additional channels of utility delivery [Matzen and Andreasen 2006].

Arguably, both service supplier and user can be said to be part of the same transformation, but dividing the process model into two separate process planes emphasises the importance of defining the specific responsibilities of each participating actor. Depending on the actual life phase activity being modelled, the balance of activity can shift between processes being solely executed by the user, the supplier or in any level of collaboration between the two. For certain processes there might even be more institutional actors and thus process planes defined.

Operators representing competence input into the process

For each process plane in the PTrS (Figure 39) there can be four types of operators involved. The operators are part of, supporting and enabling the process and the categorisation into technical, human, information and management operator input is transferred unchanged from the original TrS model. When developing product offers with the aim of optimal value creation for the customer in an activity system as illustrated, in principle the provider of a PSS has more channels of value- delivery compared to a product-oriented company, which primarily delivers the product as technical means to aid the processes of the user. Similar to the service model of Tomiyama (cp. Figure 33) there is no apparent difference between the results created by products and the results created through the other operator channels, seen from the customer's result viewpoint. Unlike the service model, the PTrS links the process modelling to four concrete operator types, which the authors propose more readily can be converted into task and competence descriptions, technical requirements for contracted service partners and necessary products or tools respectively.

Consequently the proposed parallel transformation system allows the modelling of single value creation processes for the purpose of identifying the necessary inputs and operators. The division of the model into single actors' process planes furthermore allows both the representation of responsibilities and the creation of alternative delivery models. This is done by altering the division of tasks and operators between the different process planes, e.g. letting the service provider take over the human operator's tasks from the user. Optionally the consideration of substituting the contribution of one operator by another is also possible, e.g. substituting the human operators reporting tasks with an automatic IT based reporting technology.

The PTrS model of Matzen et al. [2005] has been applied in some of the case studies of this research project in order to evaluate its properties.

3.2 A new design object

For the providing firm, the expansion of the design object and the subsequent implementation of the necessary manufacturing and delivery systems imply that product development will be empowered to influence a much broader range of company functions and processes. McAloone and Tan [2005] propose the means for allowing this broader influence to be a vertical integration of organisational structures and tasks, which is illustrated in Figure 40.

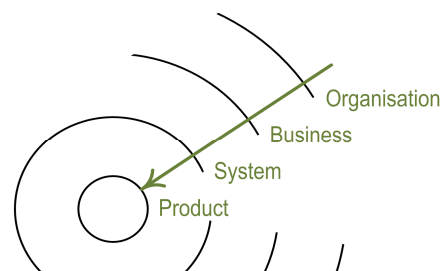


Figure 40: PSS requires vertical integration in the organisation [McAloone and Tan 2005].

McAloone and Tan argue that at the *organisational level*, it is important to create internal and external venturing between functions and competence, in order to direct the right competence and delivery capacity to those life phase activities that are targeted for additional service delivery towards the customer. At a *business level* a deep insight into stakeholder networks and portfolio dependencies is necessary in order to balance the interest between stakeholders by the creation of value transfer mechanisms. At the *system level* the understanding of product chains, supply chains, product life cycles and value chains is necessary. At the *product level* the understanding of multiple product lives, development of PSS-solutions (i.e. combinations of artefacts and service systems) and models for PSS-conceptualisation are central.

Regarding the vertical integration of development tasks in PSS, McAloone and Tan [2005] thus largely agree to e.g. Tukker et al. [2006] that PSS development includes business model development.

McAloone and Andreasen [2002] point to the time dimension in the utilisation of artefact systems and how the provider needs to build up competence and capacity to deliver support to the single product unit throughout its service life.

Compared to many other approaches of PSS design (section 2.3), service design (section 2.8) and service engineering (section 2.11), McAloone and Tan [2005] stress the necessity of considering the time span of a whole product life (a washing machine from manufacturing to disposal), while e.g. Sakao et al. [2008] focus their modelling efforts on the primary service delivery activities of the employed products (e.g. the process of washing a set of clothing).

Expanding the scope of support further, Tan et al. [2006] identify the importance of the customers activities in relation to the product's lifecycle, due to his close involvement in most of the service life activities of the product.

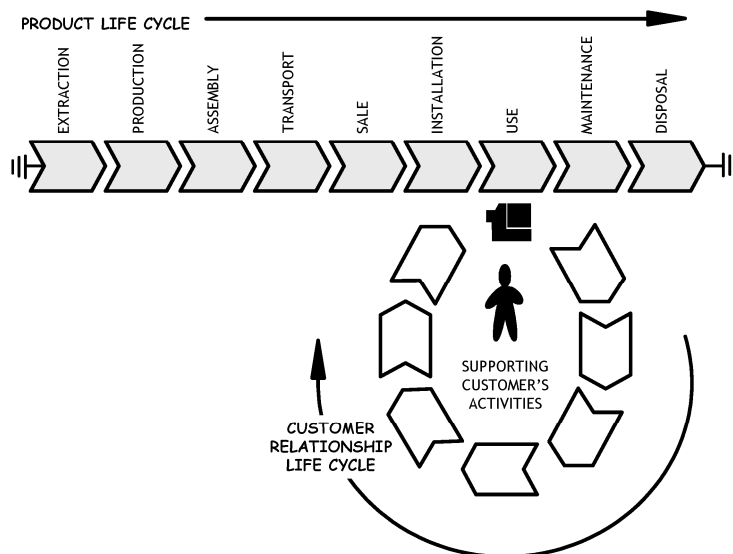


Figure 41: The two lifecycles to be considered in PSS development [Tan et al. 2006].

Figure 41 illustrates the two primary life cycles to be supported by PSS development. The linear life cycle in the top refers to the typical succession of life phases throughout a products life, while the lower cyclic part of the model represents the activities of the identified principal actor important for the utilisation life phases of the product. The model is cyclic in reference to the *customer activity cycle* model of Vandermerwe [1993] who visualised the cyclic nature of many human and corporate needs.

4 Framing the explorative investigation

Based on the review of literature in the previous chapters and the models proposed in chapter 3, the research objectives of the project are defined and three research questions regarding service oriented product development proposed. The three research questions will guide the empirical research activities.

Before the investigation of how product development can be improved within a setting of PSS, the wide field of contributions reviewed throughout the preceding chapters must be discussed in relation to the application area of this thesis.

Aiming for improved understanding of the development object and task

The research investigation aims for a contribution to the development activities of manufacturing companies supporting the *service life* of their products. In this context, the concept of *service* refers to the utility a manufactured product (in any of its many forms) delivers to its users during the so-called *service life* [McAloone and Andreasen 2002], and not to the economic categorisations of ownership and access to capacities, as discussed by Araujo and Spring [2006]. The delivery of utility has been shown to be depending on a number of factors, such as the *process* of use [Parasuraman et al. 1985; Hubka and Eder 1988; Tomiyama 2001], the *life phase system* governing the use situation [Olesen 1992; Hansen 1997] and the *actors* involved in the process or being part of the context [Vandermerwe 1999; Callon et al. 2002; Manzini et al. 2004; Donaldson et al. 2006].

Complex task of framing the focal life phases

The *service life* period of a product depends on the viewpoint taken, as different actors (users) will have different perspectives. Taking a train car of an underground line as example (thereby reusing a case described by Davies [2004]), the commuting passenger will regard the period of being transported from home to work, the period where the train delivers transport functionality to the passenger, as being the service life. The train driver (invisibly part of the passenger's service delivery process) will include the daily tasks of checking the train for defects, shunting the train into depot for maintenance etc. into his service life definition. For train-life management provider, the service life covers a period of probably several decades, in which the train operates, is upgraded to match improved signalling and control systems, renovated to remedy passengers' wear and tear on the interior and finally disassembled in order to yield spare parts to other trains.

For product development it is imperative to identify the relevant perspectives to be considered and make sure that the product and supporting service systems fit these perspectives and resulting requirements in the best possible way.

Uncertainty effects in development

Obviously, the number and variety of actors evaluating and influencing the service life depends highly on the type of product, market and the institutional relations throughout the product life, making it important to consider the succession of life phases and the possible alternative life cycles of identical products.

Recalling Olesen's [1992] theory of dispositions, stating that the products properties throughout its different life phases are defined by decisions taken in product development and the concrete impacts of the individual product life's trajectory through its various life phases, the consideration of all foreseeable life phase activities in product development is central to ensure the products satisfactory performance.

Considering the products fit to prioritised life phase activities is not new in product development, and was already established by Olesen [1992]. Within the context of PSS, where the manufacturer sets out to expand his offers by the support of life phase activities [Tan et al. 2006] through the delivery of services, the company acquires additional channels of delivery [Matzen and Andreasen 2006]. The provider becomes an active actor in the supported life phase activities, expanding the object of design in product development to include the life phase activity and life phase system configuration.

In chapter 3, models for the visualisation and analysis of both single processes (cp. Figure 39) and the life cycle phases of products and customer relationships (cp. Figure 41) have been proposed, based on literature and first experiments. The first research objective is therefore to apply the models proposed in chapter 3 to a real industrial product- and market context in order to evaluate the types of insight they lead to.

Research Question 1:

Can the key activities and actor relationships in the life cycle of an existing product/service-system be identified and analysed through the modelling of life phases and their use processes?

Assuming the analysis of existing systems and their internal and external dispositional links can create an insight foundation for the development of concepts for future products and services, the central task in service oriented product development is the synthesis of future PSS solutions. Solution elements must complement each other to deliver optimal utility to the customers, while being efficiency deliverable by the providers delivery system. The creation of a synthesis approach in service oriented product development, leading to the definition of PSS concepts is the second research objective.

Research question 2.a:

How can solution concepts be synthesised in the context of service oriented product development?

Research question 2.b:

What are the description parameters of concepts defined in the synthesis activity?

As described in chapter 2, other researchers have proposed development approaches for PSS in the past, including Tukker and Tischner [2006], Steinbach [2005] and Morelli [2006]. Common for these other approaches are that they are not explicitly embedded in or linked to the existing organisational and process structures of manufacturing firms development function. In order to support the implementation of service oriented product development in companies, it must therefore be considered how the con-

ceptualisation and development of PSS solution concepts relates to the other tasks of the development function in the manufacturing company. Therefore the third research objective is the exploration of how service oriented product development can be positioned in relation to other development tasks.

Research question 3:

How is service oriented product development related to the other development tasks of the manufacturing company?

The three research questions are attempted answered through the analysis of three case studies. The details of the chosen research strategy and the design of the case studies are described in the next chapter.

5 Research Strategy and Methods

The challenge of design science in general is to investigate the professional practice of design work, evaluate it in respect to identified problem areas or required performance changes or improvements and finally to propose measures which are expected to improve professional practice through new knowledge, processes or tools. Andreassen [2007] artistically illustrates this as a (children's) book of design science, consisting of four separate stages of activity.

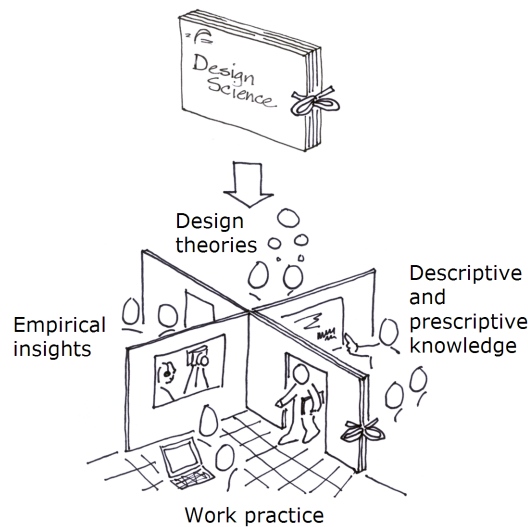


Figure 42: Artistic interpretation of the conduction of Design Research [Andreassen 2007].

Design science is aiming for different goals

While the description above infers a sequential progression from practice, empirical insight and design theory building to the formulation of descriptive and prescriptive knowledge, there is no necessity in this sequence. Many design tools and procedural models (e.g. mechanical CAD or project management models) are not rooted in defined design theories, while many design theories have been formulated without direct link to empirical investigations or the subsequent application in descriptive or prescriptive models and tools.

Horváth [2007] defines three separate design research approaches, being the so-called:

1. **Research in design context** aims for an analytical explanation of design and design practice through the formulation of theoretical models, corresponding to a clockwise progression from work practice to design theories in Figure 42. While this approach adds to the disciplinary knowledge of design, it doesn't necessarily changes design practice or results.
2. **Design inclusive research** applies a three staged approach of problem exploration, solution design and verification, in order to close the loop from identified or presumed problem, investigation of alternative solution concepts to the verification of the chosen concepts applicability and effect. The approach is the one applied

in this research and corresponds to the design research methodology [Blessing 2002; Blessing and Chakrabarti 2002] described below.

3. **Practice based design research** applies the general design or problem solving approach to create practical solutions to the perceived problem situation and subsequently evaluates the achieved results and processes through reflection exercises. While this approach per definition ensures a close coupling to the practice of designing, the results cannot always be transferred to other contexts and suffers from the researchers insider knowledge making a clear distinction between the method's and the researcher's influence difficult.

While this research is applying a design inclusive research approach (represented by the application of the design research methodology), elements of practice based design research have been applied in the case studies to evaluate the applicability of proposed modelling techniques, by their practical application to company specific tasks.

5.1 Research methodology

The present research is aiming for a contribution to systematic product development from a tradition of engineering design research and the so-called *design research methodology (DRM)* [Blessing 2002; Blessing and Chakrabarti 2002] was chosen as a natural methodology framework for the research work.

Blessing and Chakrabarti [2002] emphasise a number of defining properties of design research, in which the broad field differs from most other research disciplines and thus necessitates the definition of a specific methodology. Fundamentally, the research not only seeks to establish insights into the principles or practice of design work, but rather aims for the alteration of practice through the development of normative measures. Therefore the DRM is divided into four general stages, as illustrated in Figure 44:

1. The initial identification and definition of the problem to be solved, setting the criteria for subsequent measures' success
2. The conduction of a first descriptive study to identify the factors influencing the problem area
3. The development of normative measures such as guidelines, methods or tools, aiming to solve the perceived problem situation
4. The conduction of a second descriptive study, evaluating the impact and effect of the normative measures' application

CRITERIA	DESCRIPTIVE	PRESCRIPTIVE	DESCRIPTIVE
FORMULATION	STUDY I	STUDY	STUDY II
Review	Detailed	Detailed	Initial

Figure 43: The positioning of this research within the DRM framework.

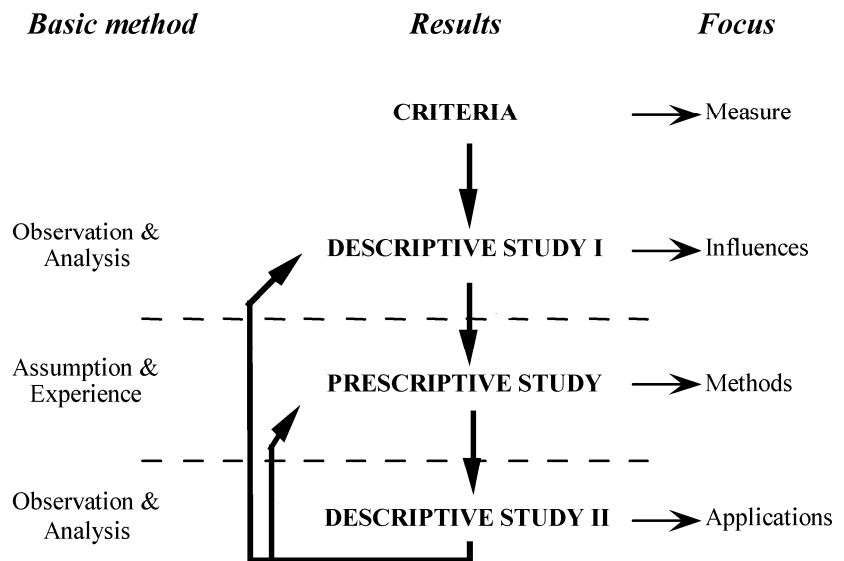


Figure 44: DRM framework including the main progression steps and iterations.
[Blessing and Chakrabarti 2002]

Blessing and Chakrabarti [2002] underline that the framework in Figure 44 is not to be strictly understood to be a sequential progression from one stage to the next, but rather is the frame for an iterative process throughout long term research efforts and that any single research project (such as the present) will only be covering parts of the generic DRM framework, due to the restrictions in time, research resources etc. The present research is positioned within the DRM framework as illustrated in Figure 43.

Formulation of criteria for the research work

The research is based on the research work presented in chapter 3, which is setting the frame for the formulation of the research questions for the research project in chapter 4.

Descriptive study based on literature and case studies

In the three case studies, comprising the main empirical insight contributing to the research, the hypotheses of chapter 3 are broken down to concrete research questions and investigated in the selected case companies. A number of different modelling techniques are identified and evaluated initially in the literature review in chapter 2. The modelling methods and tools which are found the most promising for the aid of service-oriented product development are then adapted to the application in the case studies.

Prescriptive study evolving from the analysis of the cases studies

From the application of the methods and tools in the cases, forming the descriptive study (I) of the research project, the methods are reviewed and developed further in the analysis chapters 9 to 11, thereby being converted to the resulting systematic approach to service-oriented product development, which is the main research contribution.

Initial evaluation of prescriptive models by case study practitioners

Finally, the resulting systematic approach is presented to the respondents of the case study companies in order to yield an initial descriptive evaluation of the applicability in the industrial sectors researched into.

5.2 Case study research strategy

For the gathering of empirical evidence in the research project, a case study research strategy as described and defined by Yin [1994] is applied:

1. *A case study is an empirical inquiry that*
 - *investigates a contemporary phenomenon within its real-life context, especially when*
 - *the boundaries between phenomenon and context are not clearly evident.*
- ...
2. *The case study inquiry*
 - *cope with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result*
 - *relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result*
 - *benefits from the prior development of theoretical propositions to guide data collection and analysis.*

from [Yin 1994, p. 13]

The case study research strategy seems well suited for the research subject of PSS due to several reasons, mostly related to the fact that the research aims for insights into how product and business development is conducted in manufacturing firms:

1. The phenomenon of “product development” cannot be divorced from its contextual setting within the firm, as it is influenced and relies on informational and resource exchange with all other company functions. It might not even be explicitly evident to the participating actors that they are conducting development work.
2. The research questions posed in chapter 4 aim for an exploration of information sources, necessary competence and formation of decisions, all per definition unknown prior to the investigation and thus not separable from the study context.

Ensuring the validity and quality of studies

To ensure the quality of the design and execution of the case studies presented in the thesis, the four tests listed in the Table 5 below have been considered and used for evaluation.

Table 5: Tactics for evaluating research design quality. After [Yin 1994, p. 33].

Test	Options of evaluation	Phase of application
Construct validity	Multiple Sources	Data collection
	Establishing chain of evidence	Data collection
	Review of case study report	Report composition
Internal validity	Pattern matching of data vs. propositions	Data analysis
External validity	Replication logic between cases	Research design
	Use of protocol and template	Data collection
Reliability	Case study database or material archive for revision	Data collection

5.2.1 Study design

A multiple case study with multiple embedded units of analysis

The first decision in the research design process regards the selection of case study type. Yin [1994] categorises 4 basic types in a matrix of single or

multiple cases, yielding either one or multiple units of analysis each. Given the area of inquiry and the hypotheses stated in chapter 3, a multiple case design is chosen. It pays tribute to the exploratory character of the research project and the consequential need to contrast different company contexts, in order to evaluate the general applicability of case insights. With a single case design, the aim of generalising possible insights to cover more than the single company or maybe a very specific technology or market context would not meet the quality criteria of either external validity or construct validity of Table 5. The three cases presented in this thesis represent different manufacturing firms, each coping with the challenges of moving from product to service orientation. Due to the nature of their product, organisation and market situation, the three companies are approaching the change process differently, and also position themselves on different levels of progression and readiness regarding a service orientation of their business. By analysing and comparing three cases it is anticipated that more valuable insights regarding the defined research hypotheses are possible, increasing the general result validity.

Through the research project, different data collection and analysis methods are applied, ranging from semi structured interviews, workshop interview sessions to document analysis and analysis of own and students' action research work. Within each case, both the organisation and conduction of product and service development, as well as the composition of the company product offer, is investigated, resulting in several embedded units of analysis for each case.

According to Flyvbjerg [2006, p. 230] and Yin [1994, pp. 38-54]), the selection of cases for the multiple case study can follow 6 different strategies, which are described in Table 6 below.

Table 6: Strategies for the selection of samples and cases [Flyvbjerg 2006]

Type of selection	Purpose
A Random selection	To avoid systematic biases in the sample. The sample's size is decisive for generalization.
1 Random sample	To achieve a representative sample that allows for generalization for the entire population.
2 Stratified sample	To generalize for specially selected subgroups within the population.
B Information oriented selection	To maximize the utility of information from small samples and single cases. Cases are selected on the basis of expectations about their information content.
1 Extreme/Deviant cases	To obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense.
2 Maximum variation cases	To obtain information about the significance of various circumstances for case process and outcome (e.g., three to four cases that are very different on one dimension: size, form of organization, location, budget).
3 Critical cases	To achieve information that permits logical deductions of the type, "If this is (not) valid for this case, then it applies to all (no) cases."
4 Paradigmatic cases	To develop a metaphor or establish a school for the domain that the case concerns.

5.2.2 Selection of cases

The three main cases described in this thesis are selected to represent a variety of manufacturing firms currently in the transition from pure product to product/service orientation in product development. The three companies are all component suppliers positioned deep in their respective value chains regarding the products end users. All three traditionally compete on their product business parameters, primarily related to cost and quality. While Acta and Novenco FF are both involved as sub-suppliers of safety equipment to the shipbuilding industry where authority regulation set the standard for possible developments, Danfoss is chosen to represent a different industrial context of volume manufacturing of controls for a narrow segment within refrigeration technology, where the development competition in terms of improved performance and shorter product generation life cycles is more prevalent. All companies are experiencing an increase in service activity, both in terms of market demand (in the Danfoss case) and supported by regulative opportunities (in the cases of Novenco and Acta).

While Acta and Novenco represent similar companies in terms of their market context, they can jointly be compared and contrasted to Danfoss. The two groups allow the evaluation of a number of parameters in the discussion of both approaches to and opportunities inherent in service oriented business. Danfoss represents one of the leading suppliers in refrigeration controls in contrast to which Novenco and Acta are relatively small compared to both their competitors and customers. The technology development pace in refrigeration controls is high, implied in part by the rapid developments in communication and information technology, while the development in the fire fighting and crane equipment businesses is focusing more on manufacturing optimisation and projecting efficiency.

Some of the main case company characteristics are collected in Table 7. The company size column represents the total turnover of the enterprises, not the business units being part of the case study. The size indication serves mainly in relation to considering the three companies support infrastructure in terms of IT systems, global presence, marketing support, process support, negotiation power etc.

Table 7: Key variation parameters between the three chosen case studies

Case company	Revenue in €	Technology	Business model	PSS experience	Customers
Acta	8 Mio.	Marine crane equipment	Engineer to order	Introduction of inspection and certification system	Shipyards
Novenco FF	100 Mio.	Marine fire fighting systems	Design to order	Traditional after sales services and spare part sales	Shipyards
Danfoss FR	2980 Mio.	Refrigeration controls	Mass manufacturing	Existing service support business for key account customers	Contractors OEM FR enterprises

The two marine sub suppliers were part of a larger collaboration project aiming for service-orientation of the Danish marine industry, adding an element of balanced cross enterprise network development, while Danfoss is positioned in a more powerful situation in relation to their delivery partners in the food retail (FR) business.

Finally Danfoss lends itself for the investigation of existing service delivery systems, as the company has an established service support contracting business supporting their product sales in the food retail market.

5.2.3 Interaction and data acquisition methods

Data acquisitions mainly based on employee interviews

Throughout the case studies, the main data acquisition methods were semi structured interviews and workshop sessions with company employees. Secondary sources of insight were the analysis of internal and public documents of the companies, general technical and legal/regulation literature and semi structured interviews with external stakeholders. The two studies in the shipbuilding context were conducted within the framework of a larger collaboration project in collaboration with the Danish Maritime organisation of shipyards and maritime sub suppliers. The collaboration yielded additional insights from discussions with other companies and stakeholders in the maritime and shipbuilding business.

Combination of observations and participatory research

While the studies of Danfoss and Acta primarily were based on interviews, the study of Novenco had a participatory character, where the researcher took the role of an external advisor. Throughout the study, the company structure and value propositions were analysed, and a number of concepts for a service-orientation of the business unit's activities were presented.

5.3 Analysis methods employed

The data gathered through the interviews, workshops and discussions conducted throughout the case study projects was structured and analysed using four methods. The methods were chosen and developed to support the creation of a rich image of the case companies' activities regarding different life cycle phases of their products and to explore both the knowledge held by the study participants, but also to identify gaps in relation to life phases and activities.

5.3.1 Iterative exploration as key method

In all three case studies the analysis of interview data was performed using an iterative exploration method [Robson 1993].

After each session, the session recordings were rehearsed and statements were documented in a report, then the data material, including documents, notes and annotations on posters, was reviewed. Based on these initial analyses, a memorandum containing the main statements and initial findings was written and returned to the session participants for review.

Based on the initial analysis and feedback from the participants, the preliminary results were used to construct graphical models of the product life phases, activities, mobilised actor networks and customer activities respectively (see descriptions in the following sections). These models represented the preliminary case results, which were then fed back to the participating company personnel in the following workshop sessions.

In consecutive sessions, the preliminary results were presented on posters or as printed slides, such as the example in Figure 45. Throughout the sessions, the participants were first introduced to the current models format and content, after which they were encouraged to note corrections and additions throughout the workshop discussion. After each session the new

results were again analysed as described above and the models were refined for later iterations.

Through the conduction of a number of iteration loops, the final analysis models emerged.

As the workshop sessions were held with different participants of the respective companies, the results were refined and triangulated [Robson 1993] throughout the conduction of the case study, to ensure that the final analysis results were valid and differences of perception between participants were identified.

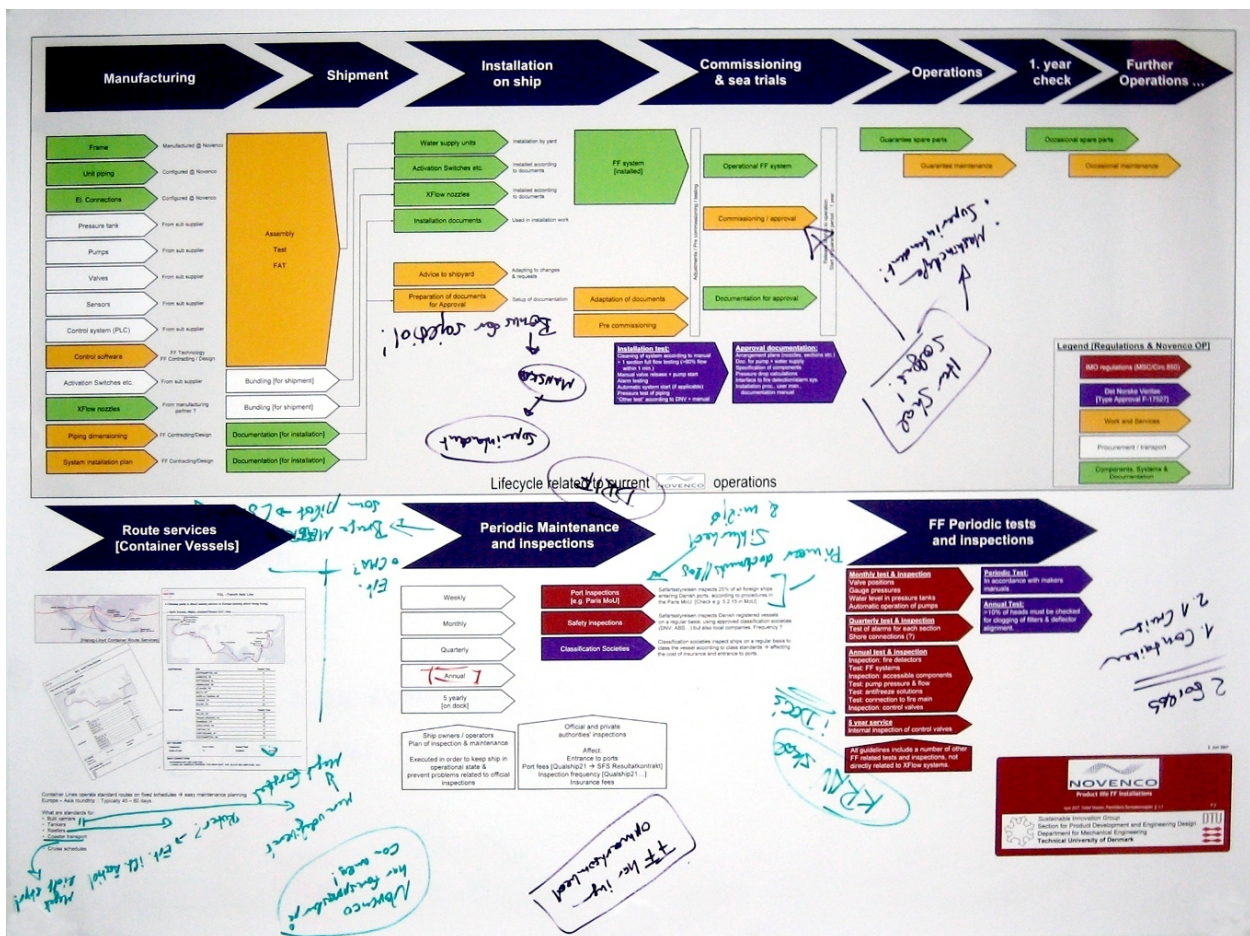


Figure 45: Example of a poster used for iterative exploration in the data analysis.

The four modelling schemes used in the case studies are described below.

5.3.2 Product life phase diagram

The product life phase diagram (an example is shown on the poster in Figure 45) is a graphical model used to visualise main life phases of technical systems and identify primary activities, requirements and stakeholders associated with them. The modelling technique used in the case studies of this research project was inspired by the so-called *Product life gallery* technique used in teaching contexts at DTU [McAloon 2007]. The complete product

life diagram resulting from the case study with Novenco is shown in Figure 48.

The product life phase diagram is a graphical representation of a products complete life cycle, and can be used to identify life cycle activities, needs arising in their execution and properties of the product in relation to the specific product life activities.

The creation of the product life phase diagram is done through the following steps:

- The main life phases of the technology under investigation are identified.
- Single activities executed throughout the life phases are identified.

After these two first steps, the diagram can be utilised to represent a number of different influences on the technical system:

- Identification of crossing life cycles and their impact on performance, environmental impacts etc. (cp. Figure 22).
- Identification of manufacturers offers in regard to specific life phases and activities (cp. Figure 48).
- Requirements set from actors regarding performance, processes etc. in regard to specific life phases and activities (cp. Figure 45).

The life phase diagram allows the discussion and identification of activities, products and services following the chronological life cycle of technical systems. In this way it mirrors the customer focused modelling of activities done by help of the *activity modelling cycle* (AMC), described in section 5.3.4.

For selected processes specific for one particular life phase activity, these have been modelled applying the TrS model of Hubka and Eder [1988] described in section 2.10. A simplified representation of one of the models is shown in Figure 50.

Due to the complexity of graphically modelling the specific life phase activity processes, these models have not been used in the iterative process with the participants from the case study companies.

5.3.3 Actor network modelling

Graphical delivery network representations have been used to represent the flow of material and information associated with delivery activities [Manzini et al. 2004] and the flow model of used in the area of *service engineering* employs a data node actor network modelling approach for the representation of relations between different actors in the service supply chain [Shimomura et al. 2008]. In science and technology studies, actor network theory has been suggested to explore how physical items and humans interact and meaning is created through the building of practices of use [Latour 1991; Latour 1999].

In order to identify possible beneficial service activities throughout the product life, it is important to know the constellation of all possible stakeholders in the relevant product life phase and particular activities. Different stakeholders (or actors) may have different motivation, benefit and cost associated with specific operations, and knowing these relationships and interests can assist in the subsequent design of delivery networks, as these only can function properly if the involved actors benefit from them and no

major conflicts arise. The use of actor networks in design has been described by Donaldson [2006] in terms of a tool called *customer value chain analysis*, and McAloone and Bey [2008] have developed a tool for interactive application in workshops with product life phase stakeholders, that maps the mobilised network of actors for specific activities and identifies their relations and interests.

In the case studies of this contribution, a similar modelling technique has been used, that is based on the analysis of interview data. Analysing the insights gathered through interviews and workshop sessions, the researcher identified stakeholders and mapped their relations in reference to specific life phases or life phase activities. The results are represented graphically, such as illustrated by Figure 46, and can be fed back to interviewees for validation and refinement purposes.

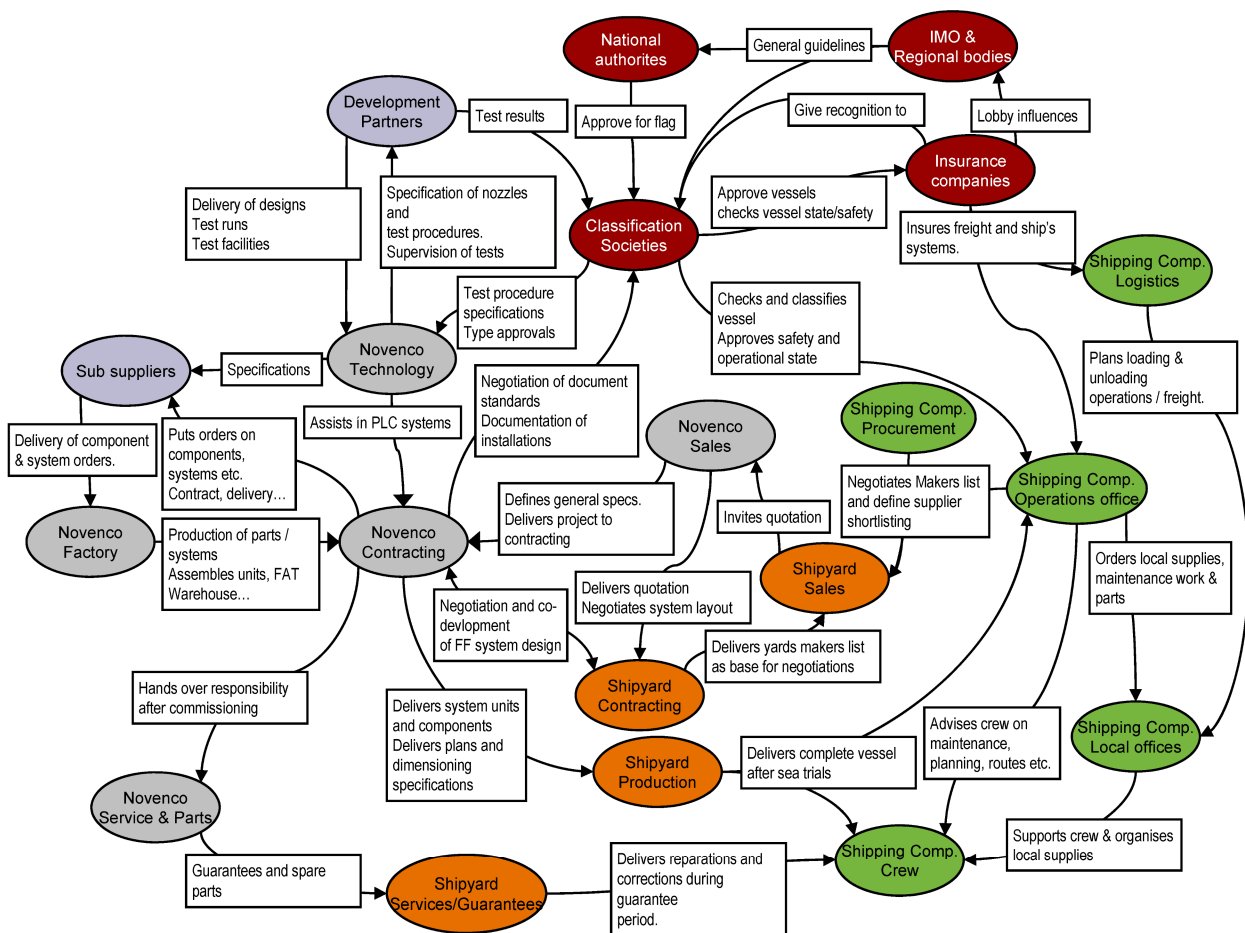


Figure 46: Partial actor network indicating institutional actor's deliveries in the shipping industry.

In the illustration, only the deliveries between different institutional actors in the shipping industry are represented. The colour coding indicates the relations between single actors (which are represented on the department level), while deliveries are described in short texts.

Equivalent models can be set up for information, product, financial or service flows, as described by McAloone and Bey [2008].

5.3.4 Customer activity modelling

Since the actor network model represents the complete network of stakeholders involved in the analysed life phase or business, it can be difficult to see the prioritisation of relationships and the importance of specific links to the further development of products or services.

In order to model the customer's activities in relation to the technology of the company, an activity modelling method was applied, which was developed in an earlier collaboration project in the shipbuilding industry. A detailed description of the method is published by Matzen and McAloone [2006]. The method builds on the so-called customer activity cycle (CAC) model that was first presented by Vandermerwe [1993] and is illustrated in Figure 25.

The so-called activity modelling cycle (AMC) is a graphical information model, which prompts the researcher to consider the company customer's activities and the structures of the changing mobilised actor networks in an integrated fashion while constructing the graphical model representation.

The customer or primary stakeholder has to be identified as focal actor around which the analysis will revolve. Most of the work throughout the analysis will be directed towards identifying the primary stakeholder's interests and activities. The analysis builds on the identification of a primary sequence of activities of the focal stakeholder, related to the product or technology under investigation. In the case of maritime equipment, as illustrated in Figure 47, the focal stakeholder could be chosen to be the ship owner, while the sequence of activity follows the life cycle of a merchant vessel through the life phases from contracting, commissioning, operation and re-approval to sales or wrecking. After the primary activities are identified, the mobilised networks of actors influencing the particular activities are investigated and depicted in the model.

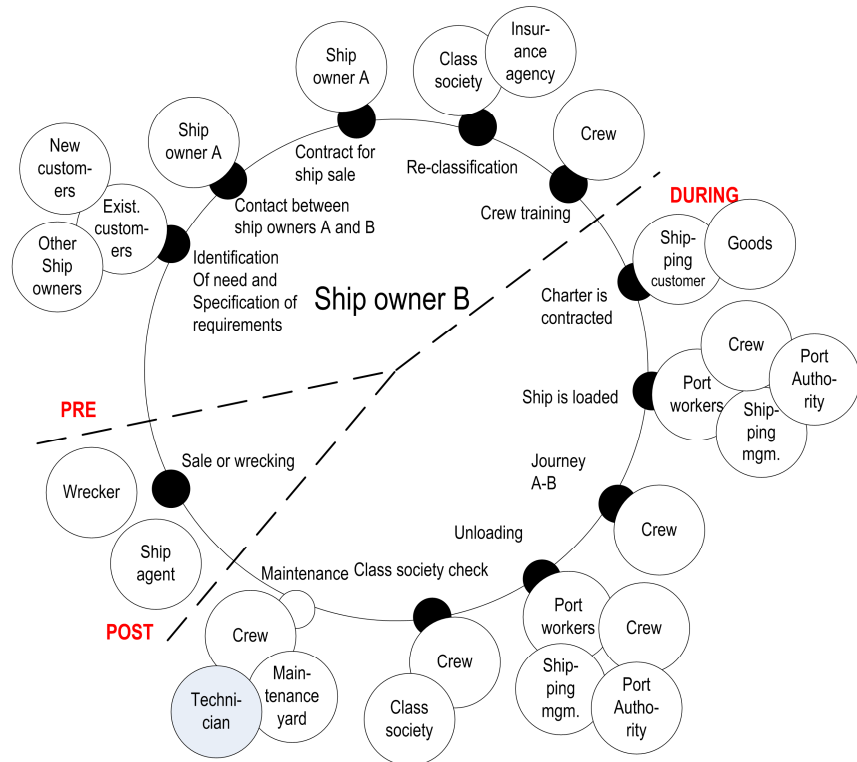


Figure 47: Example of a CAC model visualising the activities of a ship owner associated with a ship [Bay et al. 2006].

The model can be redrawn in several versions in order to illustrate the most important performance requirements for single activities or to propose possible changes to the sequence of activities and the networks associated with the specific activities.

The advantage of the AMC model is that only activities associated with one focal stakeholder are illustrated, easing the identification of primary activities suitable for introducing changes to network or delivery mode.

The AMC technique can also be utilised to identify how interactions and networks change over the course of the customer's sequence of activities, thereby introducing a time dimension into the actor network modelling activity.

6 Case study: Novenco Fire Fighting

Reassessing their approach to the after sales and service market, the Danish company Novenco analysed the opportunities of offering proactive services regarding one of their divisions product programme of fire fighting systems. The case describes the company's products service life properties, the options of introducing PSS business models and the resulting requirements on the company's other activities.

6.1 The case company and context

A contracting based manufacturing company

Novenco manufactures equipment for installation in ships, maritime constructions and the land-based construction industry. The main business areas of Novenco are heat, ventilation and air conditioning (HVAC) equipment and water-based fixed fire fighting (FF) systems. The company has about 550 employees and is generating an annual turnover of roughly 100 million euro. Prior to the case study investigation, Novenco had changed ownership from a larger globally operating HVAC provider for buildings and industry to a Danish equity fund. With independence came the need to restructure part of the distribution and after sales services network, which used to be shared with the former owners. Not the least due to these changes, the company was in the process of redefining their after sales strategy and the options of service delivery.

Studying one business unit to obtain a holistic context situation

The business unit responsible for the manufacture and contracting of water-based fixed fire fighting (FF) installations for maritime and land applications was chosen as context for the case investigation. The case study focused on the maritime FF business area, due to the obvious options of offering inspection services, which are mandatory for safety equipment on ships as regulated by the international SOLAS convention [IMO 2004] and enforced by national authorities' and classification societies' representatives around the globe.

National maritime authorities and independent classification societies are the main institutional actors regarding the inspection and control of safety and technical reliability of ships and marine structures. Every merchant ship must be registered in the registers of a national authority, which in turn ensures that the vessel fulfils the national regulations regarding safety, reliability and pollution. Although exceptions exist, most national regulations are aligned with the general guidelines defined by the *International Maritime Organisation*, which is the maritime body of the *United Nations*. The national authorities are responsible for the conduction of annual inspections of the vessels registered under their flag. Furthermore the local authorities are responsible for the conduction of inspections on board foreign vessels entering their ports, which is called *Port State Control (PSC)*. The PSC activities of the authorities of large geographic regions (such as e.g. Western Europe) are coordinating their efforts to be able to follow up on ships found not to comply with regulation. The national authorities ultimately have the right to detain ships from further operation, if severe deficiencies regarding risks of safety, reliability of pollution are found on board.

The **classification societies** (class societies or class) are independent technical service organisations, most of which originate from the large ship insurance companies. Historically the societies had the task of approving the structural quality of new build vessels, in order to enable the insurance companies to calculate their risk and consequently insurance premium levels. While this still holds true, the classification societies have broadened their services to cover the general technical assessment of ships and their equipment as well as general technical and organisational quality certification activities.

In general, all technical equipment on board ships has to be approved by a classification society. Type approvals are issued for manufactured components based on type testing and design reviews. Complete operational systems on board are finally approved during a commissioning and test run voyage. For ships in operation the classification society certifying the ships approval executes both regular and random inspection visits. Every 5 years most classification societies call for a recommissioning visit, where the vessel is docked and thoroughly inspected.

Globally there exist about 20 classification societies. While there is no official ranking, the approval requirements vary significantly. The results are differences of approval cost, insurance cost and coverage and consequentially the charters contractible and lease rates obtainable by the shipping company owning the ship.

A traditional but developing manufacturing organisation

The FF business unit was organised following a traditional pattern, with departments for (regionally and application divided) sales, contracting and technology. These were supported by manufacturing, supply chain and the service and parts departments, which were shared with the other business units in the enterprise. Due to the aforementioned restructuring processes, the FF business unit's manufacturing, procurement and service departments were separated from the other BU of the company during the study period. Some of the manufacturing activities were later outsourced, but this has not affected the tasks and challenges of after sales operation or organisation.

Service department responsibilities and development as unit of analysis

The Service and Parts department (S&P) of the company was the focal part of the organisation throughout the case study and was throughout the study in the process of restructuring and developing the company's approach to after sales services and business.

6.2 Study aims and questions

Discussing collaborative service supply networks

The contact to Novenco was initiated through the Danish maritime branch organisation's after-sales network. The researcher took part in the network meetings as facilitator of discussions regarding the possibility of forming a collaborative after-sales approach, covering a broad range of Danish marine suppliers. Novenco was reconsidering their global service supply network strategy and the possibility of branding Danish suppliers' servicing competences globally seemed beneficial for Novenco.

Conceptualising approach to service activities

In the process of conceptualising the strategic development options, Novenco was reconsidering their general approach to after-sales services. They had realised that a more proactive approach to service offers and activities was required to fulfil the service department's strategic business growth goal. The S&P department therefore invited the researcher to create concepts for a service oriented business approach for Novenco FF, while allowing use of Novenco as a research case. The company expected to gain insights on how the sales and contracting activities of the company could be aligned with a service oriented strategy, and what activities should be in focus for a future after-sales department.

Study objectives

For the case study, the main aim was to analyse the suitability of the com-

pany business model to the planned introduction of proactive after sales activities. In order to identify the critical links between the company setup and the resulting service performance, the dispositional effects between company activity and service life performance were to be identified. Therefore the study's main objectives were to investigate:

1. the dispositional mechanisms linking decisions regarding product design to service life performance.
2. the dispositional mechanisms linking decisions regarding system design and contracting to service life performance.

6.3 Research and analysis methods applied

Participatory research

The research work carried out in this case was of participatory character, with the researcher having the role of an external advisor, while investigating and analysing the current product portfolio and development approach taken by the company. The case study was conducted within the frame of a concept development project, where there were developed a number of potential concepts for a service offer portfolio.

Information was gathered through a series of meetings in the form of informal interviews, workshop sessions and continual intervention under the course of the case study with department and project managers of the FF business unit. Throughout the study, the following employees of the company acted as informants to the case:

- Managers of S&P, Contracting, Sales and Technology
- Project Managers within Contracting and S&P development
- The director and service manager of the FF business unit

The main information sources have been the company employees, where the majority of the interventions took the format of discussion meetings, held with the partners in the S&P department. Furthermore a sales representative from a customer company and the DTU professor of maritime technology were included in the study.

Interview and workshop sessions

The first round of meetings was conducted as semi-structured interviews. Here the interview partners were first introduced to the project aim of after-sales concept development, and thereafter subjected to approximately 30 open ended questions, grouped in themes such as "contracting process", "product properties", "customer contact" etc. The interview part of the meeting was scheduled for 1-1½ hours per respondent and individual questions were specified for each respondent. The respondents' answers were recorded, analysed and used in the creation of a set of posters in preparation for the second round of meetings while also laying the foundation of the research analyses documented in this case study.

The second round of meetings was set up as workshop sessions. A tentative product lifecycle and life phase activity model of FF installations was presented as a preparation for the workshop on a number of large posters. Based on the posters (cp. Figure 45) and a brief introduction, the participating employees were asked to comment and annotate changes and additions. Also these workshop meetings were recorded and while the respondents were encouraged to note comments and additions on the prepared

posters, their answers and the discussion results were also captured on paper by the researcher.

Throughout the remainder of the project further data was gathered from internal and public documents, as well as additional interviews with the externals mentioned previously. Further meetings with the manager and a project manager of the S&P department were held to discuss the project state and request further documents, contacts and comments throughout the process.

Evaluation and validation meeting

The project results were finally presented to the business unit's new director and also to the service manager of the FF business unit, to discuss implications and relevance considering the new organisational situation.

Applied analysis methods and processing of insights

Throughout the discussions with the informants in the company, the focus was on questioning the different employees regarding their contribution to supporting FF customers, the relations between the different functional units in the company and the perception of service oriented business approaches in the maritime industry in general. The data gathered in meetings, workshops and literature was then converted using the modelling approaches described in section 5.3. For every round of meetings with the company contacts, the current modelling results were presented to the partners and discussed in order to update the data pool with their deeper insight and perception of the modelled state-of-the-art data. Through these iteration loops it was possible to deepen the analysis while ensuring to keep a close link to the professional insights of the company employees and yield ambitious though realistic suggestions for the company's strategic shift towards a service oriented business approach.

First the product life of FF components and systems was modelled into a sequence of general phases and corresponding activities. Those activities which were evaluated as important for the development of improved service support, i.e. primarily the activities not yet being explicitly considered part of Novenco's responsibility or influence were then attempted modelled in terms of concrete transformations. Based on the modelled transformational processes and the identified directly involved operators, the corresponding mobilised actor networks supporting those activities were drawn up.

In order to generate a general picture of the market and the technology context, the existing actor networks covering the company's traditional business model were also constructed.

In relation to the concept generation of service concepts, the opportunities of changing existing network constellations and the feasibility of entering actively into servicing activities either directly or through network partners was explored in collaboration with the company partners.

The following sections summarise the insights important for answering the stated study questions for this thesis.

6.4 Market context of Novenco FF

Product sales based on pre selection by shipyards and ship owner

The business model prevailing in the shipbuilding industry did not support a pre-purchase sale of in-service life support per se. The shipyard as a mediator between Novenco FF and the end customer did not promote service life issues, as negotiations covered all ship equipment and traditionally fo-

	<p>cused on the contracting phase of the ship (as opposed to post maiden voyage support). Concretely, both the shipyards and larger ship owning companies traditionally maintained a list of preferred suppliers of components and systems, called the “makers list”. When a new build was contracted, the ship owner and shipyard negotiated and compiled the makers list for the ship or series in question, after which the prospective sub suppliers of systems (such as Novenco) were contacted with a supply tender.</p> <p>The company (as most actors in the maritime business) employed a combination of an internal company sales force supported by a global network of associated agents. Sales agents were usually rewarded a fixed yearly payment and sales provisions for representing Novenco FF towards their local customer groups. The sales force primarily focused on shipping companies’ equipment procurement and shipyards contracting functions.</p> <p>The quotation normally referred to delivery of equipment, design services and spare parts kits. Design services included dimensioning calculations, a specification of further necessary standard components and installation instructions, which were approved by the class society in question as part of the delivery. Novenco FF was also responsible for the final test of the installed system before the new build was approved and maintenance claims arising within a technical guarantee period of 1 year.</p>
Few contact opportunities between supplier and end customers or users	<p>Depending on the ship owner’s safety and quality standards, the selection of FF system suppliers in the contracting phase of the ship was often left with the contracting shipyard and consequently based on their standard makers list. As the negotiation between shipyard and prospective owner generally focused on building cost and price, the Novenco systems were in danger of being sacrificed in budget negotiations, due to the higher initial installation cost over some of the alternatives unless the ship owner specifically insisted on Novenco systems.</p> <p>In case Novenco FF was chosen as supplier, there was still very limited contact to the end customers and end users. In the commissioning process, the FF project manager would be instructing the first crew regarding operation and might meet the superintendent responsible for the ships maintenance. While this gave opportunities of introducing to service life requirements and service delivery options, the commissioning schedules usually were tight and there was little time for a service sales negotiation.</p>
Weakened network to subsequent ship owners	<p>After the ship’s release for operation, Novenco had few options of reaching the responsible staff within the ship owner organisation. This condition worsened further as ships were normally sold to new ship owners after some years of operation, thus weakening the contact network further. This implied that while the support and maintenance of FF systems got more important as ships were operating and consequently subject to wear, the options for Novenco of reaching the right actors within the operator’s organisation diminished.</p>
Reactive approach to maintenance and spare part sales	<p>After the end of the warranty period, Novenco sold maintenance services and spare parts upon request by customers. Spare parts were usually sold at fixed standard prices, which in some cases hindered small service suppliers in using original spare parts, due to their reselling margin becoming too slim.</p> <p>To conclude on the current situation, the business model and process of Novenco FF was not aligned to parallel sales of technical systems and</p>

product life services. There was no defined service offer portfolio (equivalent to the abstract goods concept of [Callon et al. 2002]) except for spare parts distribution, and no dedicated service sales contact was attempted to ship owner personnel (e.g. superintendents) responsible for safe and efficient operation of the ship.

The case exemplified the importance of identifying and utilising the actor-network related to service life phases, both in relation to product service life needs and to establish contact for sales and efficient delivery. The actor-network influencing decisions and being part of product life activities changed repeatedly throughout the vessels service life, and from the perspective of a service supplier it was crucially important not only to fit the delivery patterns to the specific life phase and activity, but also to anticipate network shifts from life phase to life phase (e.g. different customers or operational vs. maintenance activities), in order to enable the mobilisation of beneficial service delivery activities.

6.5 Product life

In order to analyse the service life performance and support needs of FF systems, the product life phases and activities were modelled based on the interview results. A graphical model supporting the descriptions below is provided in Figure 48.

Based on the company's portfolio of components and standard system designs, the product life of specific installations began with negotiations between sales personnel and prospective customers.

Sales and contracting

The contracted FF system's general specifications were defined in negotiation between the FF salesman and the shipyard. Based on the resulting contract, the contracting department project manager designed and configured the system and sourced the components from sub suppliers and the manufacturing department.

Deliverables of the contracting process

The FF system shipped from the company included pump units, feed water and pressure tanks, control systems, nozzles and sensors, depending on application, size and integration with other safety systems on board. The shipyards installation process was guided by a manual, which also defined specifications for components the shipyard would be sourcing locally, such as piping and pipe brackets.

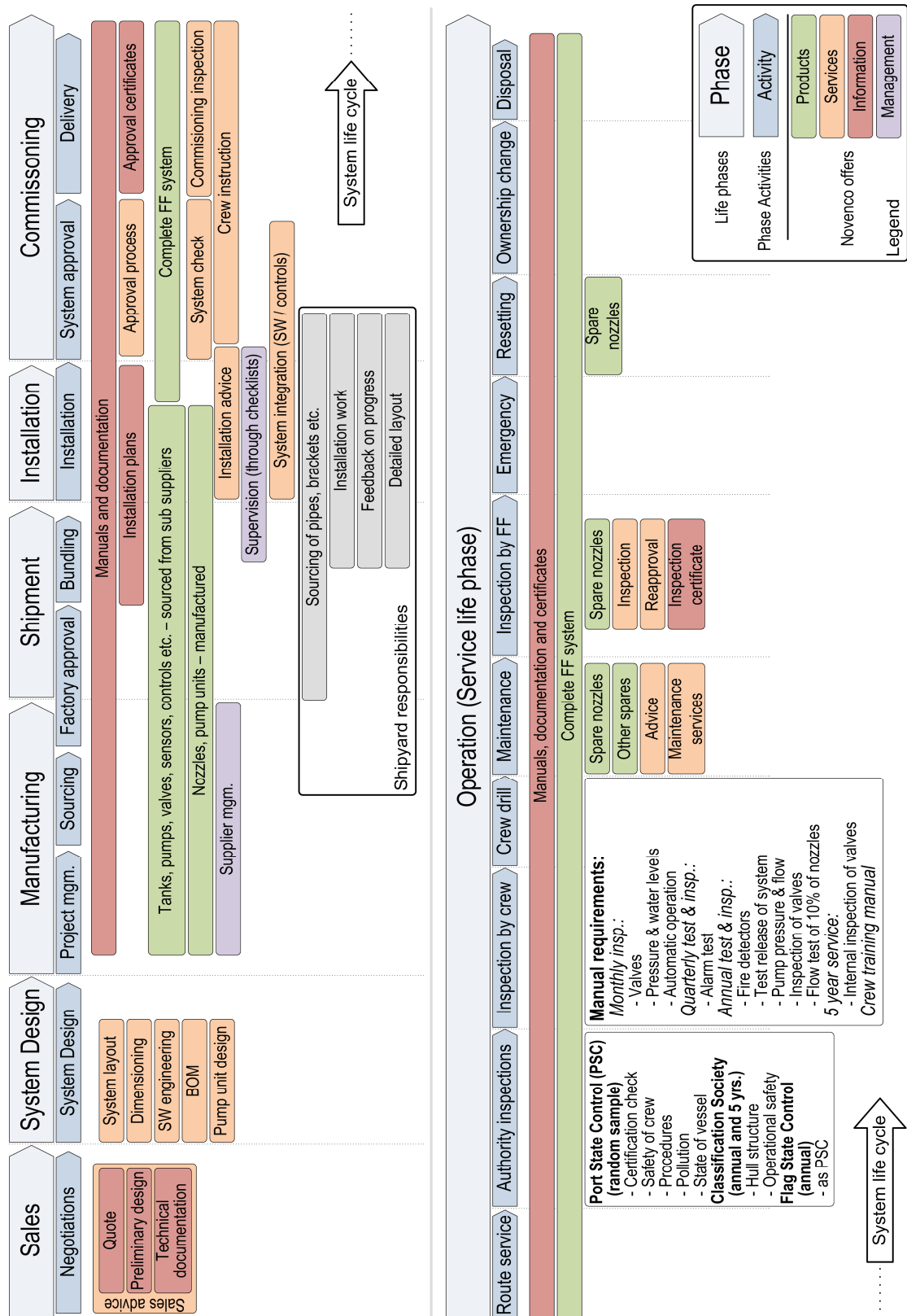


Figure 48: Product life phase diagram of Novenco FF system with indication of offered products and services.

Installation and commissioning

The various sub-systems were assembled and tested in the company manufacturing plant, then dismantled and shipped to the contracting shipyard for installation on-board the ship. In the documentation from Novenco FF the positioning and connection pattern of the spray nozzles was defined, but the positioning, orientation and support of the pipe work was only specified by general rules. This practice led to a number of risks regarding wear, corrosion and clogging of nozzles:

1. Bleed valves, used to drain out impurities and air from wet FF installations, were often placed inaccessibly or hidden behind wall sheathing, which hindered necessary maintenance operation and inspections by both crew and Novenco technicians.
2. The material quality of pipes not always fulfilled specification, resulting in corrosion problems.
3. Piping work not always followed specification, resulting in corrosion or physical wear due to air pockets in pipes, vibration etc.

During the installation, the project manager kept track of the installation state through a so-called mechanical completion list; a checklist on which the shipyard marked the completed installation stages. The list enabled the project manager to organise and schedule the pre-commissioning (if part of the contract) and commissioning visits. Commissioning consisted of a final compliance and installation check, configuration of controls and a test run. Commissioning was usually supervised by representatives of the shipyard, the classification society registering the ship and often also the ship owner.

Even though the Novenco FF was responsible for the final approval and commissioning of the system, there normally was not enough time and resources available for the FF project managers to thoroughly check the installed system for the issues mentioned above in the course of the commissioning task. This situation was often worsened by the fact that the shipyard personnel marked the categories of the mechanical completion list completed before the work was actually done, leaving a number of pending tasks to be completed very close to the test run scheduled for the ship.

In the case, several respondents suggested increasing the number of project manager visits to the installing shipyard in order to supervise the installation work, but the company was unsure about how to finance or reward this activity. This was especially true within the current business model, since Novenco was not made responsible for any non warranty based service activity and hence there was no incitement for Novenco to ensure optimal accessibility and serviceability.

When Novenco transferred responsibility for certain product life phases to other actors such as the shipyard, while attempting to reclaim it in later life phases, manuals, agreements and requirements for these life phases' activities were to be well defined and compliance assured. Especially in the maritime industry and regarding safety installations, Novenco had to distribute tasks and responsibility regarding system operation between the crew, the customers shore based organisation and service suppliers, as the ship is mobile and often not accessible.

Handover to after sales support after commissioning

After the system was commissioned and the ship released for its test voyage, responsibility within Novenco was transferred to S&P, who executed necessary maintenance during the warranty period of usually one year and supplied spare parts (usually in the form of predefined kits) to customers.

Operational pattern of FF systems

The warranty period of ships was usually concluded with a technical check of the ship by the ship owner and selected sub suppliers, not always including Novenco FF.

Being a safety installation, FF systems were not released or operated on a regular basis. Daily use was therefore limited to crew drills, technical inspections, component or system tests and preventive maintenance of the system by the ship's crew or shore personnel, which was to be conducted according to Novenco FF's instruction manuals defining weekly, monthly, quarterly, yearly and five-yearly cycles. If the system was actually released in either a test, crew drill or an actual emergency situation, the system needed to be checked and reset properly in order to function as intended. Nevertheless the operator or crew not always complied with the defined maintenance rules. This led to both safety hazards and the risk of detention of the ship if the system proved non operational or not complying to set standards in random or scheduled checks by class or port authority representatives. E.g. the ClassNK port state control report of 2007 [NKK 2007] documents that about 20% of all detainable deficiencies arise from faulty fire safety measures on board. The FF system was one of the measures in that statistical category.

Correct operation is audited by authorities

In principle, Novenco FF defined how, when and by whom the system's operational state was ensured, via the delivered manual. Depending on the classification society classing the ship and the national authority registering the vessel, the original manufacturer in some cases held exclusive rights to reapprove the systems operational state by conducting regular inspections and issuing compliance certificates, which in case of Novenco was done upon request on a case to case basis. All operational activities, such as inspections, drills and maintenance events were usually documented in the logbook of the ship. This log was checked in class and authority inspections, where the actual entries in the log were compared to the requirements stated in manuals and authority regulation. Also necessary certificates were checked for their validity by inspecting authorities. The requirements imposed by Novenco FF manuals, classification requirements and national authority regulation guided and framed the responsibility distribution for inspection, drill and maintenance activities. This led to a confusing plethora of possible combinations due to the many different combinations of class and national registers (whom each had their separate set of operational requirements).

Reconfiguration and repairs throughout service life

S&P were not aware of how much or how often systems were reconfigured or repaired, as after-sales activities were largely customer initiated and many customers relied on third party spare parts and service suppliers. Maintenance tasks included the exchange of:

- piping due to mechanical (e.g. vibration) wear, accidents or corrosion.
- sensors, due to wear, accidents or simply because they accidentally get painted.
- valves and pump components due to wear and corrosion.
- nozzles due to release (for wet systems) or corrosion.

Finally, the reconfiguration of control systems due to upgrades or changes in the other control systems on board was not unusual.

Responsibility for maintenance and support

In the shipping industry, ship owners traditionally have relied on the technical skills of their crew for maintaining the ship's equipment, partly due to the fact that ships in open water are only seldom accessible. As labour cost rose and it got increasingly difficult to recruit skilled and experienced personnel, shipping companies increasingly had to transfer technical management responsibilities to shore based superintendents and operation support offices. The ship's crew was responsible for daily operation and necessary unscheduled repairs on-board. The shore based superintendent was responsible for compliance to technical inspection and maintenance cycles and schedules activities in cooperation with the crew officers. Capacity was sourced from a variety of resources, such as

- the ships own crew,
- maintenance teams of the shipping company,
- original manufacturers' service teams (such as Novenco's S&P department) or certified service suppliers,
- service companies acting as network integrators related to defined application areas (e.g. safety equipment) and linking to trusted and certified local enterprises,
- local repair yards or port offices acting as network integrators for the port region and linking to local enterprises or
- local service companies near the repair port in question.

The selection obviously depended on the needed competence, certification requirements, prioritisation of the task and time frame as off hire periods were to be avoided. The chosen sourcing strategy varied between shipping operators, depending on many factors including company size, strategy regarding the age and standard of the fleet, business model, cargo category etc.

End of life disposal

As an integral part of the ship, the FF installation was dismantled with the remainder of the ship, which usually had life expectancies between 20-40 years depending on the vessel type and operational patterns. Also spare parts used throughout the service life, e.g. used nozzles, were disposed by the customer or their service suppliers according to their respective practice.

Summary

Summarising the phases and activities of the product life, the following was concluded. Being a safety system, the FF installation was seldom operated, while it had to be reliably operational at all times. The main focus of technical service life activities thus regarded the inspection (as opposed to wear maintenance) of the system. Regarding safe operation, the main focus was on regular drills of the crew, making sure that every crew member was capable of correct operation in case an emergency situation should occur. Finally it was crucially important that all activities were documented correctly, as authority audits focused on documentation requirements since drill audits and technical tests of equipment are time consuming and authority personnel are not necessarily sufficiently acquainted to the specific systems on board.

6.6 Product properties

The Novenco FF nozzle programme was distinguished from other FF water nozzle types as they were designed for a medium water pressure of 4-12 bar, at which they produced an effective water mist for fire extinction. Thereby, the FF systems of the company combined the low water consumption of high pressure systems with the low energy requirements and simpler setup of other low pressure systems. The nozzle programme was divided into two categories:

- Open nozzles for so-called dry systems (for local equipment or total engine room protection), which relied on manual or automatic start of the water supply pump units for fire extinguishing.
- Automatic nozzles for so-called wet systems (for accommodation area protection), which relied on a permanently pressurised water supply and were activated by a heat sensitive bulb in the nozzle head.

Product design not optimised for inspection related activities

Especially accommodation FF installations, which relied on water filled pressurised pipe systems with automatic nozzle heads installed in the ceilings of protected areas, required care in relation to inspection and resetting operations. This was due to the system architecture based on automatic nozzle heads as shown in Figure 49, which were of a “single use” design, and were exchanged after release.

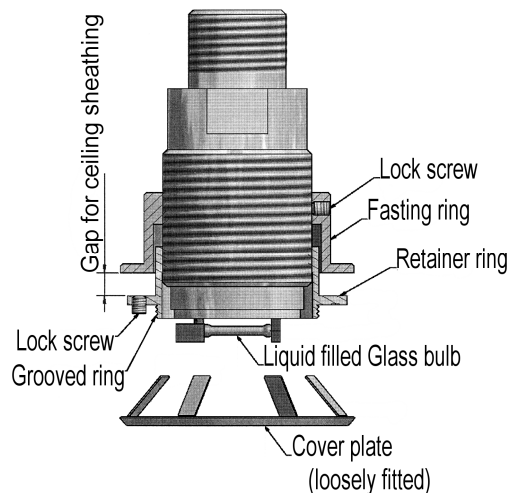


Figure 49: Spray nozzle for accommodation areas
[from Novenco FF Design manual].

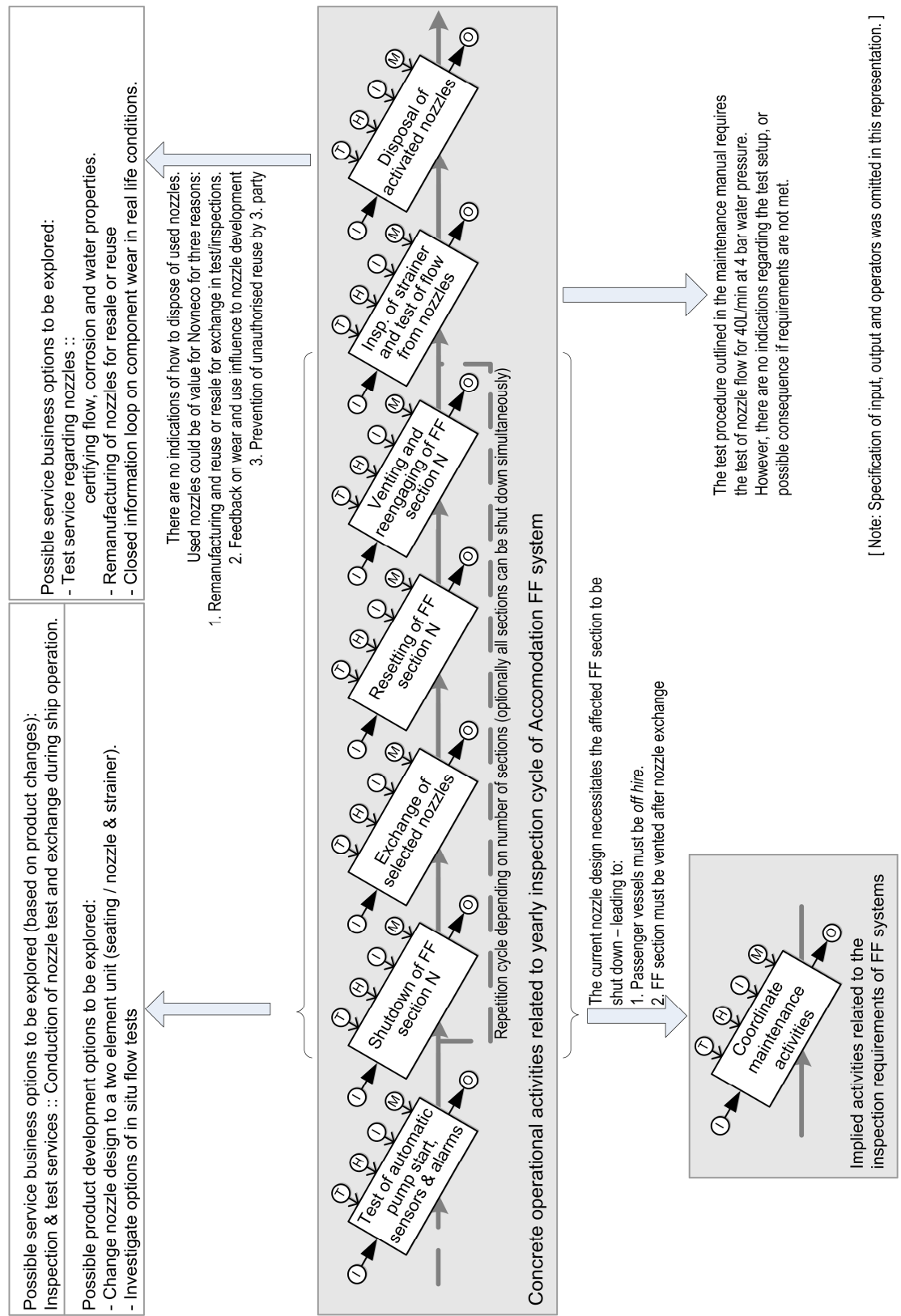


Figure 50: Modelled inspection process and derived necessary activities related to inspection of accommodation FF systems.

The nozzle type used in the wet systems was released by the breaking of a liquid-filled capsule in reaction to high temperatures (57, 93 or 141°C) or physical impact. The nozzle was connected to the FF section's water supply using the male fitting visible in the top of Figure 49. For installation purposes, the nozzle was fitted with a plastic cap protecting the bulb element during installation. This protective cap was exchanged with the decorative and protecting cover plate after installation. The IMO inspection rules, which were implemented through class societies' certification requirements, dictated that a fraction of each system's nozzles were to be subjected to destructive testing as part of yearly inspection cycles. Testing included demounting, flow testing in a test rig and subsequent disposal of the tested nozzles. In order to dismantle the nozzles of the design illustrated in Figure 49, it was necessary to drain all water from the FF section under inspection. The design implied an exchange process which was modelled as illustrated in Figure 50, meaning that:

1. Execution of inspection services was practically impossible while the ship was on duty, as draining of FF sections implied safety risks and was time consuming.
2. Due to the impracticality of exchanging nozzles, both inspections and resetting of the FF system after release was time consuming and prone to operators faults.

Considering proactive inspection services of Novenco, the inspection process was too time-consuming to be scheduled in normal route service, due to the chosen nozzle design and system architecture. Therefore annual inspections had to be performed in the rare off hire periods and in coordination with other maintenance tasks, making the scheduling difficult for suppliers and superintendents alike. In real operation, the respondents in the case study questioned whether the installed systems were actually inspected according to specification, based on the low pull on spare parts in relation to the installed base of systems.

In conclusion, the component technology was optimised for one specific product life activity, namely the actual fire extinguishing action (and the development related life phase of type and system approval). Other life phases and activities were supported as necessary, but not prioritised in the component design. Dispositional effects, of which Olesen[1992] focused on the interdependencies from product to manufacturing system and strategy, also apply to the interrelations of product, business model and service delivery system setup. In the development of products, the service life phase and its activities must be anticipated and the product design adapted accordingly.

It must be noted that a new nozzle design was under development during the case study period, which featured a check valve design that allowed the nozzle element to be exchanged while the FF system stayed operational.

Product and product development competences of FF Company

6.7 Product development function

The operational competence of Novenco FF was the engineering and dimensioning of FF systems in fulfilment of IMO regulations as well as engineering, projecting and configuration of the water supply and control systems, including sourcing of high quality, maritime approved components from approved sub suppliers. The critical component competence of Novenco FF was the product family of spray nozzles.

The nozzle is the fundamental product that FF is living off. Anybody can make a pump unit like ours and sell it, if they know the specifications.

Technology manager at Novenco FF

The spray nozzles were designed and engineered in collaboration with a sub supplier, specialising in the design and manufacture of water spray nozzles and conduction of fire tests in dedicated test facilities. In order to be used in the maritime market, the nozzles for FF systems had to be approved for compliance with IMO regulation by the various Class societies. In practice, Novenco FF conducted testing and approval activities at the engineering partner's site, supervised by Novenco technicians making sure that the required test conditions were met. The main task of the Novenco FF technology department was the specification of technical nozzle requirements, to make sure that the nozzle components fulfilled the type approval requirements and that pump units and assemblies engineered in the contracting projects could fulfil the maritime system approval requirements. The approval process was time consuming and expensive, thereby hindering frequent product generation shifts. While this market property lowered the risk of other suppliers entering the market, it also meant that product development projects needed to be well prepared and executed, as every product generation was to sustain a relatively long market lifetime.

Technology department focusing on approval requirements

Regarding the development of nozzle components, the highest priority was given to the fulfilment of stated class requirements defining quality standards regarding flow, water distribution etc. This was emphasised by the choice of outsourcing the engineering task to the nozzle supplier while retaining the management and knowledge regarding test and approval setup with the technology department.

The nozzle is developed by our development partner. We are defining the application area together with the sales department and identify the technical requirements and what approvals we need to be recognised in the market. After the development partner has thought out what type of nozzle we need, the technology [department] comes back into the game and works out how to plan and execute the necessary fire tests and build the scenario models.

Technology manager at Novenco FF

Unbalanced approach to development of standard designs

The pump units for the FF systems were generally *engineered to order* by the contracting department, utilising the technology department's competence for quality assurance tasks and advice regarding standards and approval requirements. As the main design variety of the pump units concerned the parameters of flow, pressure and the number of output sections, an alternative *configure to order* approach seemed feasible. The company did use a standard portfolio of pumps and reused existing designs where applicable, but

there were not defined explicit standard designs and design reuse was based on the engineering designers' experience and preference. The preparation of standard designs could (as stated by the respondents) reduce both the contracting and manufacturing lead time and ease the system approval process. Regarding later service activities, a standardised pump unit design would reduce the documentation load and effectively reduce the necessary competence of service personnel.

We only have a single standard unit for local protection systems, while total protection and accommodation units will never be quite identical. We are now building a basic system setup and then we can add or subtract from that basis. Until now that [issue] has been too much up to contracting, so they decided themselves and that has resulted in too many design errors. Often the classes [class societies] have different requirements e.g. regarding weld dimensions depending on materials and pipe dimensions [and the engineering designers do not always know the specific rules].

Technology manager at Novenco FF

Communication between technology and after sales

Only few efforts were made regarding the identification of service life activities and related requirements, except for the occasional feedback from other departments. In the case study this seemed to be one of the reasons for the nozzle design requiring complete shutdown of wet FF sections for the execution of inspection and maintenance tasks (as described in section 6.5). Service life related feedback from the S&P department's experiences took place through informal meetings for the occasions where S&P technicians registered multiple claims regarding certain product and component properties or had important experiences to share from their own maintenance jobs.

We are talking together, but not enough I would say. It's usually not the S&P manager we're drawing in; It's more one of the service engineers who might have had a bit too many of the same problems and then we are having a chat with him.

Technology manager at Novenco FF

To conclude, the product development function was prioritising the functional requirements of actual operation and the related approval process requirements of the components and systems, while requirements of other life phase activities and phases were not included in a structured way. In the development towards a more comprehensive approach, as stated by the attempt of standardising the pump unit portfolio, focus was on optimising pre service life phases in order to reduce Novenco's manufacturing cost and reduce lead time.

6.8 Interpretation and conclusions

The results from the analyses of this case could be drawn together to answer the three study questions that were stated in section 6.2. The conclusions and implications for the research project are summarised in the following paragraphs.

6.8.1 Important service life phases

Obviously, the highest priority performance parameter for a fire fighting system was its ability to effectively and reliably extinguish fire in an emergency situation. The FF systems of Novenco were designed to fill the gap between low and high pressure water systems in order to benefit from the advantages of both, being the low water consumption and the simple low power system design respectively. Regarding the product technology the concrete extinguishing performance and characteristics necessary to pass the required type approval tests were minimum requirements to enter the market.

Novenco also covered the important life phases of system design, sourcing and manufacturing in order to deliver complete high quality systems and assuring the correct installation in new build or retrofitted vessels through their supervision and commissioning services.

While all these elements of the company's strong value proposition were clearly visible from the product life phase diagram in Figure 48, the diagram also indicates the many important life phases which were not proactively covered by the company product-service offers.

In effect, most of the operational activities regarding the FF system were not related to the emergency release of the system, but rather to preventive inspection and maintenance activities (and their documentation).

For accommodation FF systems, which were chosen as example product type for the case study analyses, the regularly scheduled test and system inspections as required by authority regulation were identified as a key activity in the service life phase of the FF system. The inspections (and their correct documentation) were evaluated to be increasingly important for the smooth and successful passing of authority inspections, and the area represented an obvious possibility for the offering of scheduled services of the Novenco after sales organisation.

6.8.2 Product and system performance in service life activities

The accommodation nozzle component, which was analysed as example of Novenco's technology competences, clearly was primarily specified and designed to comply with the requirements of the fire extinguishing activity. As stated in section 0 the nozzle was not designed for quick and easy exchange, thereby influencing the opportunities of efficient test and inspection operations, as well as resetting of released FF sections, negatively. The product architecture required the shutdown of the complete FF section, which was not permissible when passengers were on board. Therefore the inspection and exchange activities required the ship to be put off hire, which was avoided due to the high capital cost of ship operation, and thus reduced the flexible allocation of inspection periods greatly for both crew and external service suppliers.

6.8.3 Decisions influencing service life properties

If the processes necessitated by inspection and test requirements had been considered in the design of the nozzle components and water supply system architecture, the possibility of inspecting and exchanging nozzles while the ship was on hire might have been included into the design. While the serviceability of nozzles and systems was being improved for the forthcoming product generation, the explicit consideration of service life activities in product development could have allowed for an earlier introduction of these product features for Novenco FF.

The co-development of the nozzle components in collaboration with an expert in fluid dynamics and nozzle engineering enabled the development and introduction of some of the unique technical positioning properties of Novenco FF systems (increased extinguishing effect with lower water flow and energy requirements). To balance the fluid dynamics focus of the development partners, the Novenco development function could have ensured a better fit of the component design with the many service life activities not directly associated with fire extinguishing. The component design met some of the requirements important for the installation phases (e.g. protection cap for installation purposes), but properties relating to service life activities or even the disposal of activated nozzles were not considered.

Design decisions regarding the inclusion of product features will always be a matter of prioritisation of many influencing factors, e.g. implying that some of the features supporting operational activities might be omitted to keep component manufacturing cost down, in order to match the governing business model. However, in the case company there was not made an explicit effort to predict and include the requirements of inspection or test activities into the product development process and component design. The result was poor serviceability of the FF system, restricting the options of efficient service delivery seen from Novencos point of view. In effect the lack of considering the service life requirements also reduced the actual preventive maintenance work done on board ships, as the necessary operations needed to exchange components were simply too time consuming.

In the support of service life activities, the company had taken a reactive approach and thus no defined portfolio of services existed. Inspection and maintenance tasks were executed on customers demand. This made resource planning difficult, as customer initiated service jobs required a quick response compared to possible equivalent activities based on service contracts.

Active communication to new and existing ship owners regarding the emerging regulative requirements, combined with the offering of inspection and maintenance activities based on long term subscription type contracts seemed like a viable option. Especially since most FF systems were installed on ships, the scheduling of maintenance and inspection visits to match accessible port locations could make the delivery more cost efficient. Subscription based inspection services also increased the options of gaining a larger share of spare part sales and subsequent generation of revenue from the installed system base.

Regarding the destructive test requirements of accommodation systems, there was also the option of introducing a recycling loop of nozzles. This would decrease the cost of supplying spare nozzles while giving valuable

insights into wear patterns and effective service life of the nozzle head components. Obviously the introduction of a recycling loop based system would necessitate a closer collaboration internally in the company between the production and after-sales function.

7 Case study: Acta

The small Danish maritime crane supplier Acta realised their potential of after sales service growth after the implementation of new IMO regulations in 2003. As supplier of maritime safety equipment, the company could take on the responsibility of servicing their installed base of life raft davits, and have been building an equipment servicing and certification system.

A small equipment manufacturer

Acta is a small manufacturing company, specialised in the manufacturing of cranes for ships and other off shore applications. Besides the production facilities at the headquarters in Denmark, the company sources production capacity in factories in China and Poland on a contract basis. The company, which has about 50 employees and a turnover of about €8 Mio, is a fully independent subsidiary of a larger Danish industrial group including other manufacturers of cranes and lifting equipment. Acta manufactures customer specified store-, hose-, gantry- and provision cranes, which are engineered to order from a programme of standard designs. In addition the company produces a programme of standardised of life boat davits.

Regulative requirements supporting development of inspection and certification services

Especially the business segment of life saving equipment sparked the development of service life supporting offers in the company, due to developments in the regulative context regarding their operation and maintenance. The International Maritime Organisation (IMO), which is the United Nations maritime legislative body, in 2003 published a new guideline for the servicing and maintenance of life saving equipment [IMO 2003] which was updated and expanded in 2006 [IMO 2006] and 2008 [IMO 2008]. In the guidelines the equipment manufacturer was given the responsibility and right to execute inspections, service and repair of life saving equipment onboard ships, or alternatively authorise and certify other parties to do so on his behalf. Although the IMO circulars were only guidelines and national maritime administrations could thus choose not to enforce them, it gave Acta clear incentives of establishing a service business related to the safety certification of its range of life saving [IMO 2004] related equipment. Using the imposed inspection service needs of the safety equipment customers as a lever for growing its service business Acta was also considering offering other types of services in order to form a general portfolio of service offers.

The case study is focusing on how the company approached the development of service offers related to their manufactured products, and how the delivery system necessary for the execution of services on a global market was prepared.

7.1 Study aims and questions

Discussing the options of collaborative service supply networks

The contact to Acta was initiated through the Danish maritime branch organisation's after-sales network. As invited participant in the network meetings, the researcher took part in discussions regarding the construction of a collaborative service supply network of Danish maritime equipment manufacturers. Acta were anticipating becoming part of an operational network with other suppliers, in order to reduce the risks inherent in the implementation of a global service delivery system.

Supporting the building of service collaboration

Acta was in the process of implementing a certification system for the company's safety equipment, based on contracts with independent service companies on a global scale. The company invited the author to support the continued development of their service system, while granting insights into the process and the company's challenges in general.

Study propositions

The case study's main aim was to investigate the challenges the company faced in the implementation of a global service support system. The situation of the company, being in the transitional phase of acknowledging their opportunities in assuming responsibility of their product's service life activities, was well suited to investigate the transition challenges of a small company. The study objectives were:

- to investigate the approach taken to the development of a dedicated service life supporting delivery system.
- to identify the challenges faced internally and externally in implementing service delivery systems in a small manufacturing company.

7.2 Research and analysis methods applied

Information was gathered through meetings in the form of informal interviews with the service manager and the managing director of Acta and the gathering of data from internal and public documents, especially the company's service certification database and communication tools.

The interview and document data was analysed using the methods described in section 5.3, through which the following models were created:

- The product life of the company product line was categorised into phases and main activities were identified.
- The main product life activities were filtered to identify the activities central for the service life support of company products.
- Based on the analysis, approaches for service delivery were generated and discussed with the contacts in the company.
- The processes currently associated with service delivery activities were investigated through observations made within the company.

Regulation influence initiated service orientation development

7.3 Study findings

The passing of circular 1093 by the IMO marine safety council [IMO 2003] in 2003, changed the market situation of Acta in respect to the provision of product life support. Although only a guideline, the circular officially appointed Acta responsible for ensuring the operational safety and functionality of davits and life raft launching devices originally delivered by the company. Two important aspects in respect to the guideline requirements were the following:

- The responsible authority (usually national registers or port state control) could allow third party suppliers to perform inspections and certification in case the manufacturer (e.g. Acta) was unable to execute these services. Otherwise, the manufacturer retained the right to authorise third party suppliers if he chose to do so.
- The manufacturer was entitled to define how inspection and maintenance was to be conducted through the instructions in the equipment manuals, although the circular defined a minimum list of necessary items.

As a consequence, Acta could choose to require inspection tasks regarding life saving equipment to be performed by Acta or their authorised partners only. On the other hand, this implied the necessity of implementing a global service delivery network, as the company's products were installed on ships operating globally.

Inspection and servicing of life saving equipment as one leg of service business

7.3.1 Service delivery concept based on authority requirements

The production of davits for life saving applications only accounted for about 10% of the company sales, and the company therefore also investigated other opportunities of growth for their product life service activities. In general shipping companies were lowering the headcount on board their ships to save operational cost, while the installed technical systems got more complex and servicing and maintenance thus required expert knowledge. Acta could position itself as service supplier regarding the servicing of crane and other deck equipment, diversifying from the activities related to SOLAS equipment. Service activities were also seen as one of the contact channels for the initiation of retrofit projects (exchange or upgrading of existing cranes aboard ships in operation), and retrofit sales were usually much more profitable compared to projects sold for new build ships. The company regarded the initiation of inspection service activities as a first step towards proactive after sales activities.

In anticipation of a continued move of global shipbuilding activities towards the Far East, the company predicted the decline of manufacturing activity in Denmark and Europe in future years. Nonetheless, especially European ship owners favoured European designs and components, due to prevailing quality issues and spare part supply problems of emerging Asian brands. Acta therefore evaluated the creation of a responsive and high quality service network, combined with a gradual shift from manufacturing towards engineering and projecting offers regarding new buildings, retrofit and special application cranes, as a likely future scenario.

Other product lines also targets for service delivery

The product programme of the company was based on six standard designs for hose-, store- and gantry- cranes, a variety of other deck equipment

Formalisation of a global partner network

products and the 2 families of life saving cranes (davits). The product families of davits were standardised and had to be built according to regulative requirements, but in turn did not need individual approval. All other product categories were engineered to order, and consequently had to be approved individually both for correct dimensioning and physically in a factory acceptance test survey by class society representatives.

In the initial phase of the inspection system implementation, Acta struggled to find suitable servicing partners on a global scale. They initiated contact with a number of so-called fleet stations, which were responsible for the yearly inspection of life-rafts, an inspection system that had been growing out of equivalent SOLAS regulation, but had been established many years prior to the regulations regarding launching equipment. Acta learned that although many fleet station companies were interested in partnering with Acta, the competences of the fleet station employees were (equally to many other service companies' employees) typically insufficient for crane inspection tasks. Acta therefore developed training courses for the employees of partnering service companies, in order to ensure the necessary qualifications of the workers assigned for Acta inspection jobs. The conduction of courses showed to be successful in the respect that the partner companies were typically willing to pay for employees courses, in return of achieving Acta inspection licenses. Naturally the skills of the skilled workers participating in courses differed significantly, but by conducting the training courses in-house the Acta service manager could evaluate skills of the individual partner employees, consequently allowing him to decide which tasks the different partner companies and employees would be capable of subsequently.

A first move towards service delivery, fulfilling regulation requirements

Acta chose to set up an IT supported certification system, which allowed contracted service partners to report inspections through a web based system. In return, Acta issued certificates regarding the inspected equipment, if the inspection report was evaluated as valid and the equipment was fulfilling operational requirements. The evolving prototype system was based on a database of ships equipped with Acta equipment and contained the manuals, lists of spare parts and certificates for all registered vessels.

For the registration of vessels not previously serviced, the system relied on data from the service partners. They were asked to enter the serial numbers of the cranes in question, after which Acta's service manager added the necessary documents to the database. This process setup was chosen to reduce the implementation load of adding data and to restrict the database to only contain data of vessels that actually were serviced by Acta or its partners.

The combination of a web based database system with manual evaluation of reports by the service manager allowed the service manager to keep track of the service partners' performance and skill improvements, while this setup also required a relatively high involvement. Quality problems regarding the feedback quality of contracted service suppliers were experienced regularly, but the manual reviewing system allowed the service manager to react accordingly and in the longer term to re-evaluate partner contracts. Problems arose both from cultural differences and the different competence levels of the employed local technicians.

Certification system initiating growing service business

While the simple initial setup of the IT system allowed Acta to respond to the regulation imposed requirements quickly, the system over time initiated other service activities not initially planned for. With the increasing experience and competence of the service partners, the partners in time could take over other tasks requested by ship owners. Sometimes the inspecting agent for instance was asked to survey the remaining deck equipment of the ship for necessary overhauls by Acta, thereby giving Acta the possibility of bidding on service and retrofit contracts otherwise unavailable to them.

7.3.2 Bottom up creation of a service oriented PLM system

The certification IT-system was evolving through stepwise improvements in order to support the growing inspection services orchestrated by Acta. During the case study, the researcher analysed the existing data structures and tried to predict other necessary elements in a generic data support system for service delivery systems like the one operated by Acta and marine PSS providers in general. In this work also the data management needs of other marine supplier companies visited during the research project, such as e.g. Novenco were taken into account. Not all of the identified data structures were implemented in the evolving IT-based certification system, nor was that relevant for a small company like Acta. The experiment was to consider all the data categories necessary in an information management system for maritime PSS – while in the actual case, some of the data structures were kept in separate databases or managed manually by the service manager of Acta. Figure 51 illustrates the identified requirements for a so-called Service Oriented PLM system.

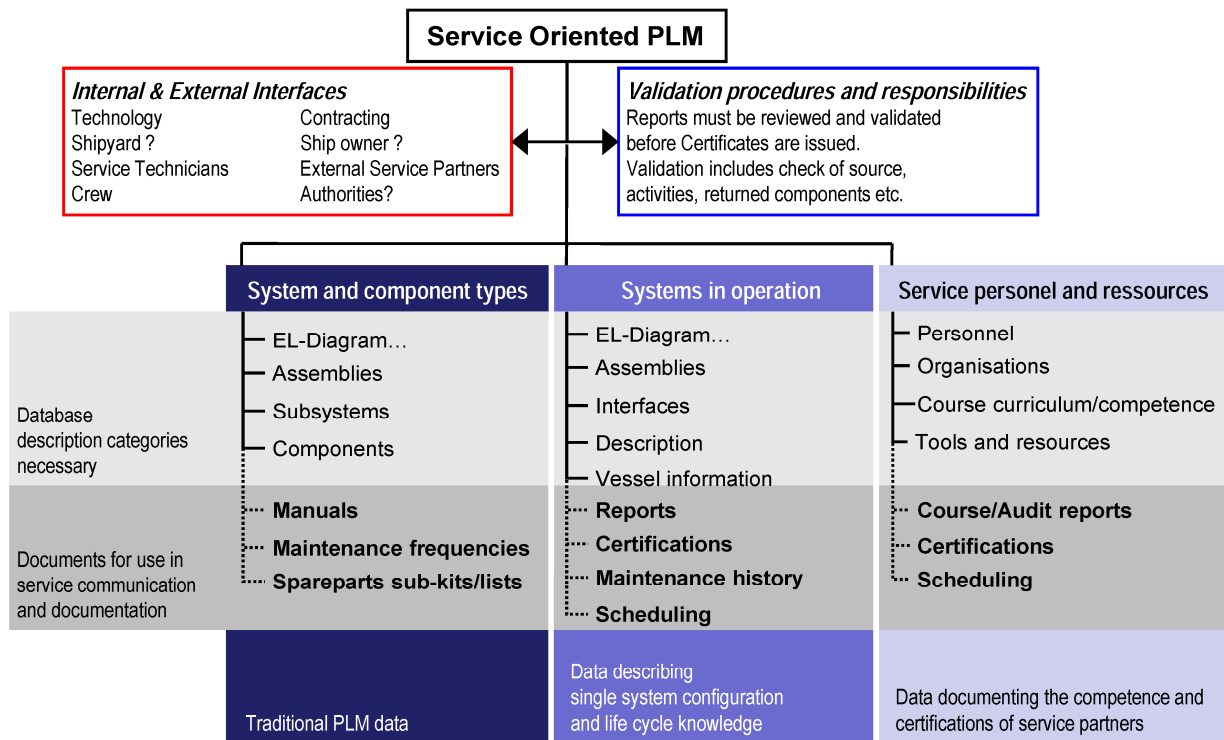


Figure 51: Tentative list of necessary elements in a PLM data system for PSS.

The figures lower part shows three pillars of data content, each divided into data content describing the entities (upper part) and the documents which can be generated from the data in the lower part. The three pillars identified are:

1. **System and component data.** The information contained in this category largely covers the information usually managed in existing PLM systems. It represents the documentation of the company's products (e.g. CAD data) and their life cycle (e.g. spare parts kits) on the type level.
2. **Data regarding systems in operation.** This category was identified as important for the support of specific instantiations of the product types described above. As most installed systems in the maritime (and most other capital goods sectors) are effectively unique, every installed system requires to be separately documented. In the case of a PSS business approach, this documentation must be supported by data describing the relevant information gathered throughout the service life. It could include the identification of related systems (e.g. the vessel in a maritime context) the history of ownership, maintenance, wear part exchanges etc. Keeping track of the actual inspection and maintenance history would also enable the provider proactively to support the product, e.g. by contacting the current owner to arrange for planned or required inspection and maintenance jobs.
3. **Service delivery systems and resources.** The last pillar represents the PSS counterpart of traditional PLM systems' manufacturing information management. In a PSS, the product support activities, which are linked to the single system instantiations above, are delivered by a delivery system, which must be managed by the provider.

The three information management pillars obviously need to be utilised to ensure the technical and delivery quality and performance of the provider. A number of procedures and responsibilities must therefore be defined in order to keep the data structures updated and valid (illustrated by the examples in the top-right box in Figure 51). The actual application of the data stored and processed in the *service-oriented PLM* system finally must be facilitated through a number of interfaces to internal and external actors, some of which are listed in the top-right box in the figure.

7.3.3 Approach to service development based on customer experiments

While the certification system for SOLAS inspections was being implemented based on the regulation requirements, Acta considered different service delivery concepts which could broaden the company's after-sales service offer towards their existing and potential new customers.

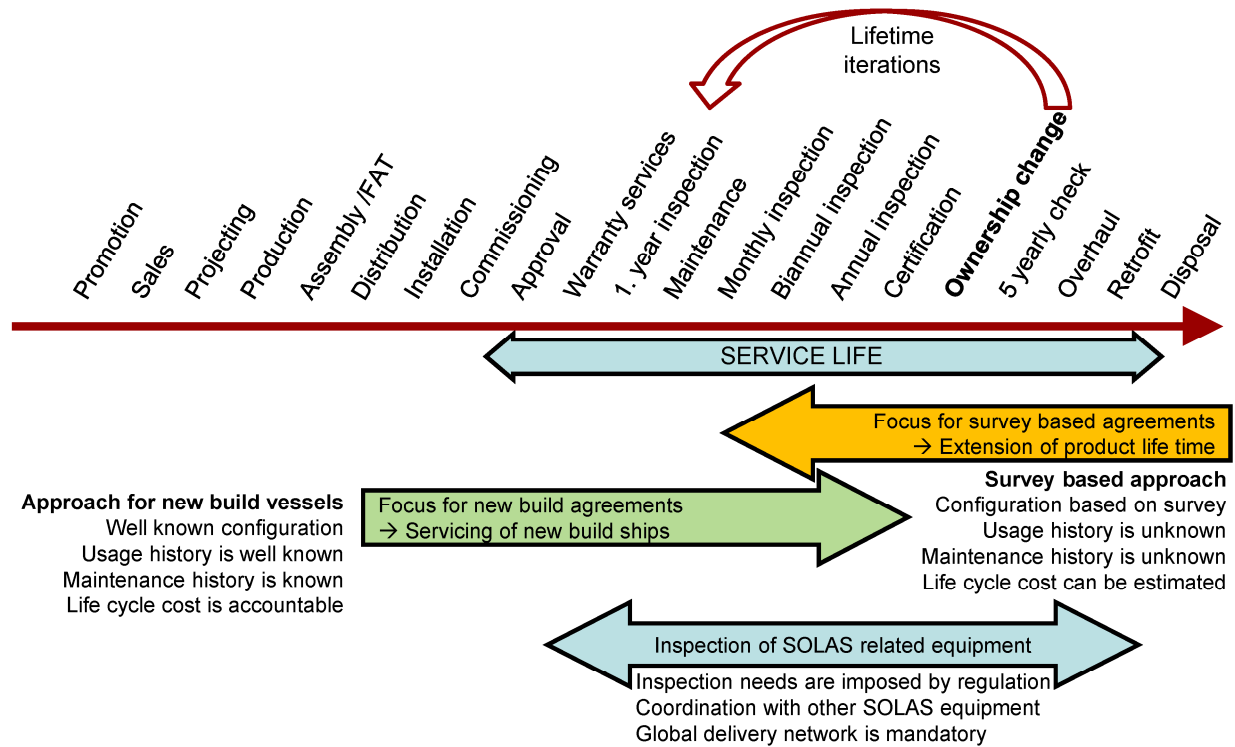


Figure 52: Three possible approaches to after-sales services considered by Acta.

From the case study interviews and discussions there emerged three main approaches, which are illustrated in Figure 52. The product life phases of the Acta equipment that would normally be the object of service agreements are identified and illustrated in the top, while the three service life related approaches to service delivery are shown in the lower part of the figure.

The first approach was based on the opportunity of entering a service contract with the prospective ship owner in the sales and contracting phases. In this scenario, Acta as sub supplier would approach the ship owner, either directly in the sales and contracting phase or in collaboration with other suppliers using the shipyard as network agent. The negotiation of service delivery contracts in the building phase of the ship seemed advantageous in the respect that the condition of ship and use history of the systems and components are known. Assuming that regular and preventive maintenance and timely exchange of wear parts reduce the risks of breakdown and need of acute maintenance work, the provider's risk of entering into a servicing or maintenance contract is much lower for service support contracts covering the product life from the beginning of its service life. Regarding the possibility of feeding back information regarding total cost of ownership (TCO) which can be used to improve product or service system design, the gathering of full information and accounting of efforts is only possible if Acta has information covering the complete service life of the service systems. The main value proposition towards the customer using this approach would be the ensuring of operational performance of Acta equipment.

Taking over inspection and maintenance tasks for new build vessels

Service agreements based on a survey of equipment state

The second approach illustrated in Figure 52 was based on the negotiation of contracts with ship owners interested in outsourcing some or all of their maintenance tasks. The process would include the surveying of the ships equipment (e.g. all deck equipment or all lifting equipment) and the subsequent contracting of service work regarding the relevant equipment on-board. Unlike the former approach, the survey based approach would have to cover a broader range of equipment types as the focus from the customer viewpoint would be on the general outsourcing of maintenance work (regardless of equipment), as opposed to the reduction of operational risk regarding a specific set of equipment delivered by Acta. The approach was planned to be initiated with a few local ship owners in order to gather experiences.

Inspection services focusing on SOLAS equipment

The third approach was gradually to broaden the service offer portfolio to cover the inspection of other SOLAS related equipment, such as life boats, fire hoses and other fire fighting equipment. Also in this scenario, the competence of delivery would have to be broadened in order to cover a diverse range of products from SCBA-apparatus to life boat launching devices and FF installations. The value proposition towards the customer would be different from the other two in its focus on the SOLAS certification and inspection needs of the ship owner. Although the business model of managing the customers' certification needs in respect to a specific set of legislative rules was straightforward, the link to the company's existing competence was rather weak.

Case by case investigation of options as development approach

In the exploration and development of the different service delivery concepts, the company took a case by case approach, starting with the necessary creation of a first preliminary inspection and certification delivery system and subsequently exploring the business options in the sequence concrete customer opportunities were identified. This was partially based on the limited resources available for service development. The other factor was the limited knowledge of both customers' requirements and the competence necessary for delivery, and in conclusion a stepwise exploration was chosen as this would keep risks down and allow for a gradual evaluation of which competences were needed and what types of services were asked for by specific customers.

7.4 Interpretation and conclusions

The development approach

Building on the existing after sales activities of the company, which were primarily based on the expertise of the existing staff of technicians, Acta took an implementation oriented *first things first* approach to the building of a proactive service delivery business. The company evaluated the requirements put forward through the legislative regulations and implemented a prototype certification system for their fulfilment. This first step was necessary in order to form a framework within which the Acta service technicians could document their inspection activities towards the ship owners. From the prototype stage, the company then explored the possibilities of geographically broadening their inspection abilities through the licensing of the company certification activities. All these developments were directly derived from the framework put forward in the IMO regulation.

Sparked by the inspection service system, Acta, and in particular the service manager developed a number of more general approaches, but without ex-

The integration between existing manufacturing competence and service activities

explicitly separating and categorising elements and general concepts. The integration of the evolving service concepts with the other functional areas of the company (e.g. sales, manufacturing, engineering design) was weak, and most interaction seemed to focus on the options of bundling service agreements with existing product sales and the options of generating activity by selling technical competence courses to licensees and service companies on a global scale.

In general the company had not defined an explicit service product portfolio, but relied on individual contact and agreements with individual ship owners.

From company management, the idea of exploring service delivery concepts through arrangements with local ship owners was encouraged, but the after sales service business was considered strictly separate from the manufacturing business. Although the concept of surveying the equipment onboard running vessels in order to propose a maintenance contract might have proven to be a good business opportunity, the approach seemed detached from the company's other activities and thus few synergy effects were to be expected.

Company management (at the time of study) considered the after sales business as a vital part of the company, but did not expect synergy effects apart from the occasional securing of retrofit projects through the service activities, and the direct business contributions based on the inspection services required by IMO regulation.

The challenges of building a global service system

The main challenge in building the service system that was implemented at the time of study were the identification and contracting of capable delivery partners on a global scale. Although many potential partners were interested in licenses for Acta equipment inspection, many did not have the technical skills necessary. This required both the close review of inspection reports from the service manager and the creation of training courses in order to ensure the skills of licensed technicians.

The development of a broader delivery concept in itself was not central for the company; as most time was spent in planning and executing the service jobs the simple inspection service concept could generate from the existing installed base of lifting equipment. Thus the development focus was on rationalising the current delivery processes, while the development of service offers, whether integrating with existing business processes or separate from them, was left to the stepwise fulfilment of concrete customers' wishes.

8 Case study: Danfoss

The Danish company Danfoss represents one of the many manufacturing companies facing the transition from product to service orientation. From a position as supplier of electromechanical components to many industries, Danfoss have bridged the gap to the end users of some of their products by introducing product life supporting services. The company has traditionally applied very structured approaches to their development work, making it interesting to investigate how development tasks relating to product life services are approached and linked with the component product development tasks and organisation.

A global component manufacturer

Danfoss A/S is a global manufacturer within the refrigeration, heating, and motion controls industries, with more than 20.000 employees. The company is organised into a number of divisions and business units, the largest of them being the Refrigeration & Air Conditioning Division (RA).

Organisational hierarchy in many layers

The RA division is organised into a hierarchy with two main branches: one responsible for sales, marketing, support and distribution; the other for product development and manufacturing. The study has been drawing on input from two departments within RA, which comprise the service delivery department RETAIL-CARE™ which is part of the Food Retail (FR) sales branch of RA, and the Electronic Controls & Sensors (DE), which is one of the manufacturing oriented business units of RA and responsible for the development of electronic refrigeration controls. The case study investigates the links between the component development and service delivery functions of the company, as exemplified by DE and RETAIL-CARE™.

Technology base supporting information based services

The controls product category is chosen for the analysis of service oriented approaches, as it:

- constitutes the main operation interface of retail refrigeration systems.
- collects data from a number of other components and processes them to adjust equipment set points and determine performance data.
- has a gateway functionality regarding the communication between the refrigeration system and the operations staff (both local and remote).

Traditionally RA was a supplier to refrigerating equipment manufacturers and refrigeration contractors. A number of years prior to the study Danfoss had been entering the retail refrigeration market as service supplier. Initially an internal venture company between the factory and sales branches of the RA organisation, the RETAIL-CARE™ department approached supermarkets directly with a service offering branded RETAIL-CARE™. After operating for a few years, the venture department was reorganised to be an integrated part of the Food Retail sales organisation.

The RETAIL-CARE™ service system is utilising the remote monitoring and control functionality of electronic refrigeration control systems, offering a portfolio of services ranging from remote monitoring, customer training, engineering services to project management contracts. All service offers are

primarily targeted at multi site food retail enterprises, each having hundreds of stores connected to RETAIL-CARE™.

Danfoss was acknowledging the need for a closer collaboration between the service and technology delivery departments for several reasons:

- To move from simple monitoring services to comprehensive remote control of FR sites, RETAIL-CARE™ needed a gateway controller technology offering a common communication platform across different controller generations.
- The DE product development sections needed insights into the operational processes and needs of different user groups, the contact to which the Danfoss internal monitoring and service departments had, due to their running operations.
- The data collected through the monitoring operations could have been analysed to yield realistic information on operational conditions of Danfoss components, typical system configurations, fault modes and frequencies.

At the time when the study was being conducted, there was no formalised collaboration between the two organisations, and both were therefore interested in an outside view on the options and possible benefits of collaborating. The Danfoss Food Retail business case was interesting as case for this thesis as it represented the move of a traditional manufacturer into a new arena of activity, supporting the use phase activities of their own products.

8.1 Study aims and questions

Study propositions

For the partners at Danfoss, the study was set up to contribute towards an improved collaboration of the two branches (i.e. DE and FR) in order to improve the benefits from being both component supplier and service company in the FR business. For the researcher, the study had two main objectives:

1. To explore the constitution of the running PSS, compare it to the theoretical PSS foundations described in chapter 3 and identify the opportunities it opened to Danfoss.
2. To identify how the company's running service system activities and their development was related to the development of new components in the DE department. According to the company representatives, the collaboration was not satisfactory at the time, and improvement options were assumed but not yet explicitly defined.

8.2 Research and analysis methods applied

The case study was based on interviews and document analysis, conducted through two rounds of analysis and meetings. The first round was utilised to get an overview of the PSS structure and the organisational units and persons involved in its development and operation. In the second round the organisational and process setup of development projects within DE and the RETAIL-CARE™ departments was inquired upon.

Information was gathered through a series of meetings and telephone interviews with department managers and employees within DE, RETAIL-CARE™ and Danfoss business support units. Throughout the study, the following employees of the company have been informing the researcher:

- The managers of component development, business development, project portfolio management and system development of DE
- The director and technicians of RETAIL-CARE™.
- The director and internal consultants of corporate business support within product development and project portfolio management.

Throughout the study work, further data was gathered from internal and public documents.

Applied analysis methods and processing of insights

Based on the observations gathered through interviews and documents, the product life of FR systems was analysed and divided into its main phases in order to identify which product life activities were covered by the RETAIL-CARE™ PSS. Actor networks were constructed for the pre service phases, as these were the main activity arena for RETAIL-CARE™ services, and for the main system operation phase, which for RETAIL-CARE™ represented the main arena where customer knowledge could be gathered for the further development of the individual customer relationship. The product life analysis and the constructed actor networks gave the fundamental insight into Danfoss' business activities regarding FR customers.

The identified gaps and properties of the offering catalogue and the delivery system set up for its operation were then analysed and related to the approaches taken to the development of products and services respectively. The finding section is followed by a conclusion chapter reflecting on the findings in relation to the development approach of PSS development as created in this thesis.

8.3 FR refrigeration life phase systems

Product service life phases

The service life of an FR installation was analysed and modelled into seven main service life phases, each with their dedicated actor network and specific activity patterns. The seven main phases are illustrated in Figure 53.

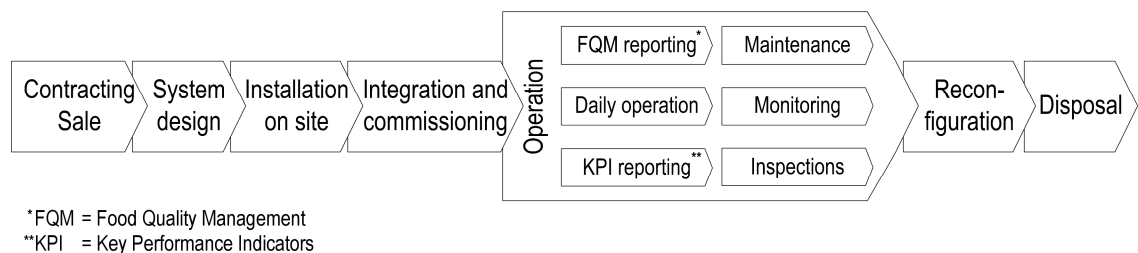


Figure 53: Main service life phases of FR refrigeration systems with main activities of the operational phase indicated.

Contracting and installation life phases

In the traditional business model, the contracting sale, design and installation of FR systems were largely done by independent contractors, which sourced Danfoss components from wholesale partners or directly from Danfoss FR. The dedicated appliance control components were normally assembled into appliances (e.g. gondolas or display cases) by OEMs and

then integrated with the store's refrigeration plant system by the contractor responsible for system design and installation. A front-end control unit, which controlled the system according to the configured control strategy chosen, enabled remote control of the system and access to data from the system's different sensors for reporting or monitoring purposes. Although Danfoss was also marketing their FR systems to food retail enterprises directly, the main contact and interaction took place through the contractor responsible for the specific system design.

The RETAIL-CARE™ business model of project management was applied to large FR customers with hundreds to thousands of store sites, shortcutting the traditional design and project management networks. Instead, RETAIL-CARE™ assigned project teams for the design and management of new build or retrofit projects, subcontracting only the physical installation tasks to local contractors.

Simplified actor networks based on the analysis of the observations regarding the first three service life phases are illustrated in Figure 54.

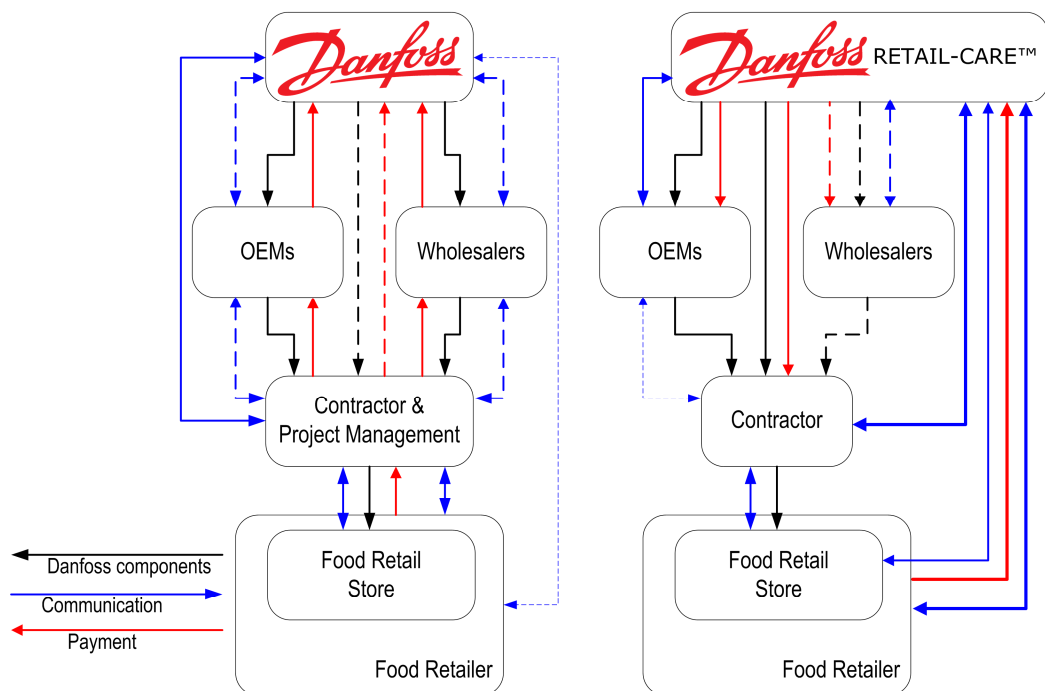


Figure 54: Actor network configurations for the first service life phases of FR systems. Traditional sales model on the left, RETAIL-CARE™ acting as project manager on the right.

Comparing the left and right side of Figure 54, Danfoss turned the relationship with some of their traditional customers upside down through entering the system contracting business. OEM's that traditionally had been sourcing appliance controls from Danfoss, were effectively turned sub suppliers of display cases for RETAIL-CARE™s system projecting teams, while the role of wholesales was reduced to logistic services of delivery. RETAIL-CARE™ thus had better options of ensuring the correct design and configuration of systems matching their components and the selection of appliances matching the requirements of their controls. As the contractor

System configuration and integration

was also sub supplying to the RETAIL-CARE™ project managers, Danfoss in effect both gained closer contact to the end customers and improved their influence in relation to assuring the quality of the installed systems.

After the installation was accomplished, the store systems were to be linked and configured for optimal operation. The automatic alarm system was also to be linked up to the correct communication channels (GSM message, telephone or internet).

For systems installed in stores being part of an FR chain, there were the additional tasks of configuring the system in order to communicate with the monitoring and remote control centre of the enterprise. Also the monitoring centre itself were to be set up and configured to be able to process the data streams from connected FR sites and remote control their refrigeration plants. Although the single store could have been controlled and operated locally by the store employees, the technological development largely displaced the operational control of the single store plant to centralised monitoring centres, which is explained further in section 8.3.1.

While the contracting company took responsibility for all integration and commissioning tasks in the traditional sales model, RETAIL-CARE™ supervised and commissioned the system configuration for projects managed by them. After commissioning the maintenance responsibility was transferred to a local service company chosen by either RETAIL-CARE™ or the customer depending on the agreed contract regarding operational supervision. The monitoring and alarm handling tasks was transferred to the RETAIL-CARE™ monitoring system.

For the life phase systems of sales, contracting and installation Danfoss FR had only minimal influence on processes and the interaction with the end customers in the traditional business model. Therefore the preparation for a subsequent monitoring contract with the end customers was primarily depending on the efforts of the initial contractor. The system design of initially self contained FR systems was not necessarily optimised for the effective integration into the RETAIL-CARE™ monitoring activities, which could impose problems in a later monitoring system integration.

For key account customers, the RETAIL-CARE™ departments attempted a reconfiguration of the contracting actor network, in order to position Danfoss in a key position regarding both the energy and performance measurement of the customer's installed base, but also the design and contracting of necessary retrofits and new store sites.

The first life phases of FR systems highly depended on the specific customer's company setup and strategy. Danfoss was operating with a number of general customer segments to be able to match their market offer in terms of both products and services to the requirements of the different customer segments. Segmentation categories included divisions between customer groups regarding issues such as:

1. Fraction of refrigeration controls energy use compared to other technical systems like lighting, HVAC, in-store production facilities (e.g. ovens), etc.
2. Local store control vs. enterprise-wide remote control of multiple stores.

3. Separation or integration of in store technical systems (refrigeration, cash registers, HVAC, lighting etc.)
4. Standardisation of technical store installations vs. individual system designs.
5. Size of the customer enterprise regarding the number and size of stores.

8.3.1 Operation of FR refrigeration plants

Danfoss estimated the accumulated yearly operational cost of a well run and maintained FR system was normally equal to the initial installation cost, the overwhelming part being energy consumption. A Danfoss contracted university study comparing two FR stores also documented that adaptive effect control of refrigeration cabinets and condensers yielded energy savings of averagely 23%, leading to a pay-back time for the more expensive control systems of less than two years in the case study [Danfoss 2007].

The complexity of maintaining an optimum setting regarding energy efficiency and the high fraction of the total cost of ownership traceable back to energy expenses created a strong factor of incentive for a development towards remote controllable and serviceable systems. For FR chains the next step was naturally the integration of monitoring tasks across all their FR stores to centralised monitoring centres, the operation of which was one of the services offered by Danfoss RETAIL-CARE™.

The service life phase of operation was governed by an actor network with different stakeholders responsible for the six main activities. Several institutional options were common, depending on the level of specialisation of service companies and the outsourcing strategies of the FR enterprise customers.

Actor network governing the operational life phase

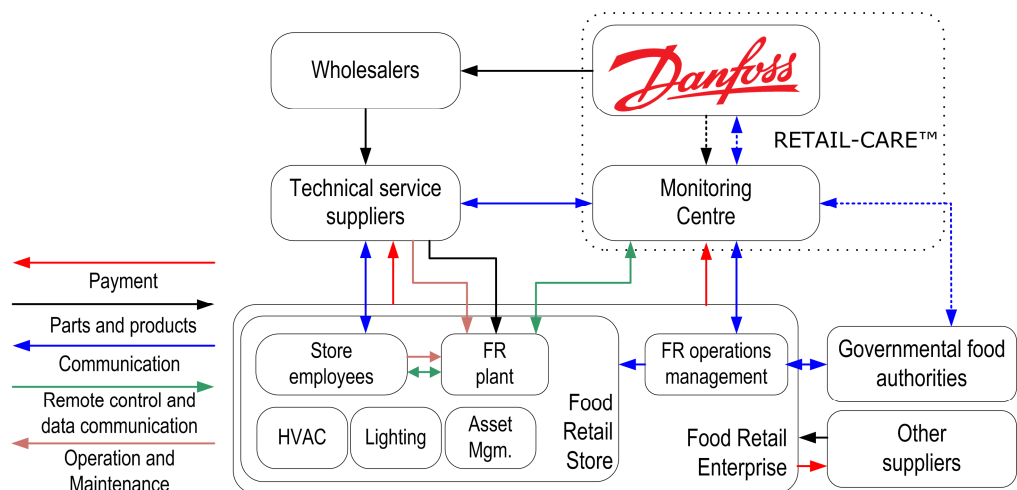


Figure 55: Active actor network in the operation life phase of FR systems.

Figure 55 represents the result of the analysis regarding the actor network governing the operation of FR plants. In the model the FR enterprise was divided into three actors, being the operations management supervising the enterprise sites and responsible for operational cost, the employees in the

Tasks of the monitoring centre

store responsible for all daily operational activities and finally the FR refrigeration plant operated in the store. In the FR store were also installed other technical systems which might have been relevant for remote monitoring and management. These included cashier systems, lightning and heating, ventilation and air conditioning (HVAC), each having their own dedicated supplier networks.

Danfoss supplied spare components via wholesale companies and the software necessary for monitoring Danfoss controllers to system houses setting up monitoring centres. In the diagram, the monitoring centre and service company responsible for maintenance tasks are shown as independent entities. In many cases these were different branches of the same service company. Many larger FR enterprises had set up internal units responsible for the monitoring of their own stores and did sometimes also implement internal maintenance units.

The data stream from the store plant allowed the monitoring centre to notify a service company for troubleshooting or maintenance tasks, in case there were operational faults detected by the system's sensors and controls.

The store log data could also be used to construct performance reports for single stores or across different stores e.g. within the FR enterprise. This monitoring of energy efficiency was key to ensure a continuous well performing system, as the quote below underlines:

In any energy management project they [the FR customer] undertake, the system will work perfectly on day one. On day two nobody knows, as service contractors will come in and make changes to the system, typically negatively affecting energy efficiency. Therefore, to achieve sustainable energy savings, the performance must be monitored and measured.

Director, RETAIL-CARE™

Services of RETAIL-CARE™

In general, the store's plant automatically stored log data locally for defined control points according to the stores food quality management (typically HACCP procedures) as included in standards like ISO22000 [2005]. The log data was processed and documented in order to fulfil the documentation requirements of the relevant authorities, which the monitoring centres could do according to the specific requirements of local authorities or collectively for all enterprise stores according to the individual customer agreement.

With the introduction of RETAIL-CARE™, Danfoss took responsibility for monitoring activities of contracted key account customers. By leaving the existing network of concrete service suppliers intact, RETAIL-CARE™ avoided the build up of dedicated service craft capacity and focused on the positions of key interest. By focusing on monitoring services regarding the operation of FR plants, Danfoss could gather data regarding their customers' plant performance, which gave them options of

- implementing quality control mechanisms regarding maintenance services.
- proposing system upgrades or retrofit projects based on real performance data.
- gaining knowledge on the company's products service life properties.

For the customers of RETAIL-CARE™, the monitoring tasks were executed by one of their globally interlinked monitoring centres, thereby linking the FR enterprise directly to Danfoss. For the customers this generally ensured a higher service level, as Danfoss had chosen to keep some of the data extractable for monitoring, some remote control functionalities and some of the algorithms allowing precise fault detection and preventive maintenance options proprietary. For Danfoss, the possibility of monitoring a broad range of food retail stores eased the possibilities of developing the monitoring software and also electronic control components further.

Expanding the use of gathered monitoring data relating to food safety and alarm handling the compilation of performance reports was utilised by Danfoss to advise customer enterprises regarding correct operation of their systems. The log data was allowing the identification of inappropriate configuration and use patterns for specific stores.

The increasing focus on keeping an unbroken cold chain from producers and throughout the FR chain's supply system also represented a growing business opportunity. As supplier of both refrigeration equipment and monitoring services, Danfoss could broaden services to include food management procedures (HACCP) for food transport and storage from producers to the final sale in the FR store. This option pointed towards one of the related life phase systems of FR refrigeration systems, namely the life phase systems of refrigerated food products.

Another broadening of services was the centralised or remote control of lighting, HVAC, and other technical assets, which was attempted by FR and DE through the development and application of corresponding dedicated controls and systems.

Reconfiguration and disposal life phases

Typical FR refrigeration systems had long lifetimes of more than 20 years, most commonly ending not because of technical wear (as the system was normally regularly inspected and maintained), but due to major changes of the shop area design and furnishing. Nevertheless, the energy efficiency performance of FR systems depended heavily on the specific configuration and the control strategies used to control e.g. compressors. This often made the performance life time of systems much shorter and in optimal conditions a major reconfiguration prior to an exchange due to wear or shop design decisions could be economically beneficial for the FR enterprise.

Normally the FR enterprise management have been calculating the options and benefits of exchanging existing with new and more efficient hardware, but the information available to the FR enterprise management was mostly lacking details and necessary conditions for obtaining the anticipated effects. Utilising the gathered data on specific configurations and systems combined with the knowledge on current controls and system components performance, RETAIL-CARE™ could leverage their knowledge of both technical systems and specific store conditions to advise their customers regarding the optimum timeframe for reconfigurations, upgrades or the exchange of complete systems.

8.4 Danfoss' service offering

The RETAIL-CARE™ service departments offered services falling into four categories:

FR business model based on product sales through a variety of channels

1. Monitoring and reporting services
2. Engineering services
3. Project management services
4. Training services

Only few of these were productised into standard service offers. Most of the standardised service offers fell into the category of monitoring services, as these were actually based on automatic data processing procedures integrated into the IT system platform.

Traditionally Danfoss had sold its FR products, e.g. controls, valves compressors and other refrigeration components, via three major distribution channels:

- OEM manufacturers of e.g. cabinets, gondolas, condensing units etc.
- Contractors designing and installing refrigeration systems for FR stores
- Wholesales companies distributing components to maintenance and service companies and partly to the other two customer groups

Through RETAIL-CARE™, Danfoss had entered into the contracting business, offering the design and installation of new FR stores and the re-commissioning and retrofitting of existing systems based on energy performance surveys, primarily targeting key account customers. The development of different regional and national markets implied varying concepts and market offer combinations depending on the maturity of the market and Danfoss' local historical presence and development path. In other FR segments and some less developed markets, all design and installation was done by independent contractor companies.

Since the event of network enabled control units and remote control possibilities, Danfoss also marketed software solutions for remote control of their installations to:

- Service and maintenance companies
- System houses designing and installing monitoring centres
- Large FR companies running their own monitoring systems

From the end customers' point of view, RETAIL-CARE™ as a service supplier was to be considered be an outsourcing provider of refrigeration management, equivalent to and in competition with other independent service suppliers, although the offered portfolio of services may have been broader than most locally operating monitoring service companies. Due to their integration with the Danfoss manufacturing business, RETAIL-CARE™ also anticipated to offer superior services regarding Danfoss technical systems, as the communication and remote control functionalities were increasingly integrated into the RETAIL-CARE™ IT-platform and applications.

In summary, the design service and RETAIL-CARE™ business units were operating in parallel to the main component sales oriented business units in FR. RETAIL-CARE™ was in the role of a growing business area complementing the traditional business especially for key account customers. For

Moving “up the value chain” towards the end customers operations

those end customers interested in outsourcing part of their operational tasks related to FR refrigeration and other asset and energy management, RETAIL-CARE™ offered a growing portfolio of standard services, heavily depending on the specific customers’ volume and sales strategic position.

With RETAIL-CARE™ Danfoss was aiming to move “up” in respect to the hierarchy levels illustrated in Figure 56. At the time RETAIL-CARE™ was started, Danfoss primarily supplied components to OEM’s and contractors. Implied by the emerging trend towards integrated remote control across FR chains a new market was created regarding the installation of necessary central network infrastructure (centralised monitoring and alarm handling) and software solutions for their operation.

While the new market of supporting the setup of monitoring centres was growing, Danfoss also initiated RETAIL-CARE™, which was an attempt to build the operational capacity of monitoring end customers’ stores internally and then sell the service of monitoring as opposed to the equipment required for it. Apart from the monitoring activities, RETAIL-CARE™ was also meant to create an internal platform for the professional management of key FR customers’ technology investments. By moving closer to key customers’ operations management, Danfoss anticipated better to be able to promote Danfoss components qualities in terms of high quality and energy efficiency, which in turn were depending on professional operation in order to perform optimally.

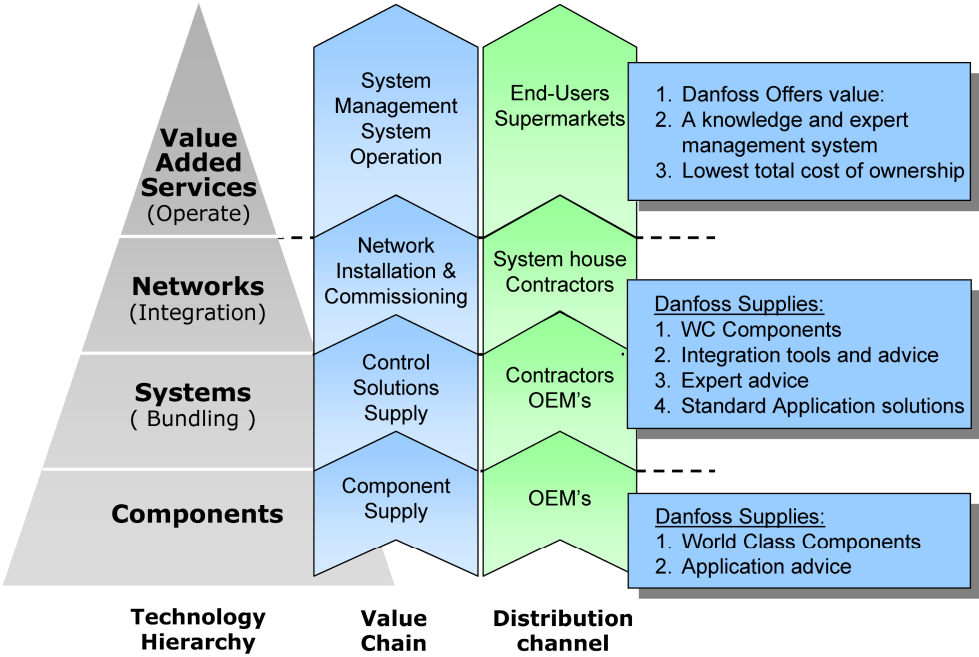


Figure 56: Danfoss perception of opportunities linked to different business models. From [Eriksen 2005]

A vision of future activities in the FR business

A categorisation of offers Danfoss was aiming for by moving into service offerings with RETAIL-CARE™ is illustrated by Figure 57. The offer category 1 largely resembled the traditional sales models of existing wholesale and direct FR sales. For category 2 some advice expertise existed within the FR sales BA, although there seemed not to be fully implemented systems

regarding the setup of enterprise solution systems yet, as the quote below refers to.

We have a good technical support organisation regarding components and systems, but the support of solutions set up is not quite at the same level yet.

Control Engineering and Applications manager, DE

Category 3, 4 and 5 were mostly to be delivered by the RETAIL-CARE™ organisation.

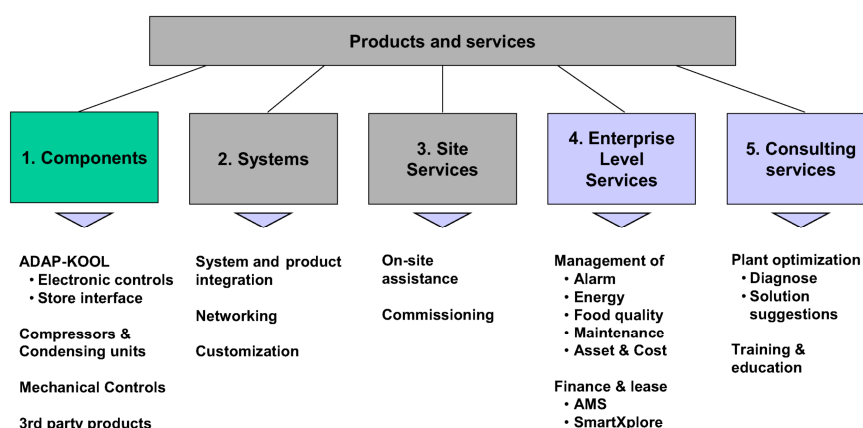


Figure 57: The anticipated categories of offers, ranging from component sales (1) over contracted solution installations (2 & 3) to service life related offerings (4 & 5). From [Eriksen 2005].

Taking the step from component to service supply

The main difference from traditional product sales was the focusing on few but important key account customers, where the developing and long lasting relationship was at the centre of attention. At the same time it was recognised that not only components, but also advice, training and other professional support was of value for customers – and thus could be turned into revenue streams for Danfoss.

A one day training course costs X amount. And we used to give that away. We used to give things away all the time. But we have come to the conclusion that if the customer values it, they will pay for it. They will pay either a direct fee, or in a commitment to buy more electronics. There is a variety of ways to bundle and package things, which are negotiated individually with every customer.


Director, RETAIL-CARE™

While many of the competences of Danfoss consultants in this way were turned into revenue generating services, they were not standardised and turned into fixed service offerings, but rather used as elements of negotiation towards the building of long lasting relationships with customers. Only few of the service offers, such as the partly automated monitoring services were stabilised into explicit offers or service levels as illustrated by the simplified service level diagram in Figure 58.

Conflicts with other market actors and internal substituting products

The knowledge gathered on specific installations performance also enabled RETAIL-CARE™ to offer re-commissioning and general retrofit of store

systems aiming for reduced energy consumption. By entering the market of retrofits and contracting of new installations RETAIL-CARE™ potentially bypassed OEMs, local entrepreneurial contractors and sometimes even competitors in the traditional sales actor network (cp. Figure 54).



	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
	SELF ANA- LYSIS	CALL CENTER	MONI- TORING	REMOTE FIX	ANA- LYTICAL
Alarm Receipt and Publication Representation of data	✓	✓	✓	✓	✓
Alarm Processing Web based interaction	✓				
Asset Alarm Notification Service centre prioritising necessary activities		✓			
Intelligent Asset Alarm Notification Active processing and check of severity			✓	✓	✓
Remote Corrective Action. Remote control regarding adjustments				✓	✓
Expert Performance Analysis & Consultation Performance reporting and proactive consultancy					✓

Figure 58: Simplified service level diagram for remote monitoring services.
Adapted from RETAIL-CARE™ material.

The Danfoss component sales also marketed software packages delivering part of the functionalities of the RETAIL-CARE™ service portfolio. This way Danfoss attempted the delivery of monitoring assistance by two means, one being the service offering of Retail Care, the other a solution coded into a software package, thereby enabling independent service companies and FR chains to set up their own monitoring systems.

8.5 Danfoss' food retail related delivery systems

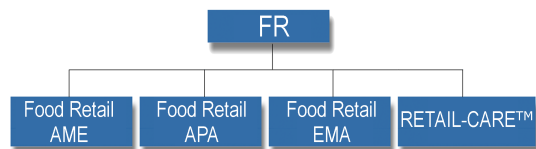


Figure 59: Simplified organisational chart of Food Retail (FR) business area departments.

The Food Retail business area was divided into three regional sales departments, the RETAIL-CARE™ department and a number of support departments, as illustrated in Figure 59. RETAIL-CARE™ was responsible for the delivery of the four service categories of monitoring, engineering, project management and training, focusing on the needs of key strategic customers. General component related marketing, training and documentation was done by the regional sales organisations. RETAIL-CARE™ also relied on

the sales departments for the general marketing and sales of RETAIL-CARE™ services, and thus had no dedicated sales force.

Due to the historical development path of the company, there were also regional differences in the organisation and branding of RETAIL-CARE™'s services. E.g. a regional contracting subsidiary, which was merged into the Danfoss group by external acquisition, caused RETAIL-CARE™ to approach that specific market more independently from the governing sales organisation and offering slightly different services compared to other regions. In other markets, the offered services of RETAIL-CARE™ also differed, both due to the varying maturity of the markets in general as well as the local competence and capacity of the Danfoss organisation.

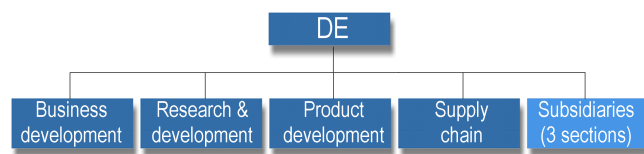


Figure 60: Simplified organisational chart of electronic refrigeration controls (DE) department.

The product delivery organisation DE was divided into further specialised groups, illustrated in Figure 60. For the study, 3 aspects regarding the organisational setup were important.

1. Business development (BD) was responsible for the maintenance and development of the product portfolio. The section ensured that there were no gaps in the product programme, that all targeted customer segments and markets remained competitive in terms of functionality and value and that new product ideas were pursued and prioritised in relation to the existing portfolio of products. Regarding product development, business development were thus given the responsibility of gathering the portfolio of new product ideas and necessary product updates to be queued into the product development pipeline. BD was also responsible for the facilitation of the so-called front-end processes of generating new project ideas and assessing them regarding their priority and feasibility.
2. Research and development (RD) and Product development (PD) formed the product development sections of DE, responsible for technology and product projects respectively. The two sections formed a matrix organisation, where the groups of RD ensured the competence and capacity regarding relevant technological areas while PD were responsible for the planning and execution of product development projects. RD ran technology projects in order to mature new technology for later application in product projects and to ensure the continuous development of product architecture and standard modules within the DE product programme.
3. Besides the four sections being responsible for development (RD and PD), management (BD) and manufacture (Supply chain) of the electronic controls programme, three other main sections resided in DE, representing one regionally separate product programme and two other subsidiaries which recently had joined the

Danfoss group through external acquisitions. The three sections were symptomatic for the organisational dynamics present in companies like Danfoss, where new acquisitions, special requirements or changing focus in markets and technologies implied regular restructuring and prevented the generally attempted functionally consistent organisational setup.

The general division between the sales and customer oriented sales organisation and the product manufacturing units clearly underlined the strategic choices of the company's top management: While the *factory* departments of DE were measured in terms of efficient development and manufacturing of components and the management of a balanced product portfolio, the *sales* organisation was responsible for the marketing and sales of these components.

This way there seemed a clear division between the *core technology* which were delivered by the DE organisation, and the sales support functions organised in the FR departments. Although the RETAIL-CARE™ service department generally could be regarded equivalent to DE in its function of service delivery, the recognition of services deliveries as being part of the offer portfolio seemed still to be in an emerging phase.

8.6 Danfoss' approach to product and service development

Well defined tasks for different development departments

Structured and documented development model for product development

The DE department developed the hardware for the portfolio of electronic controls. DE also was responsible for the development of firmware and user interface applications. The analysis, documentation and optimisation software, on which many of the service offers of RETAIL-CARE™ were based, was developed by RETAIL-CARE™ through third party partners.

In general, Danfoss applied a standardised, structured approach to product development, including process descriptions and required documents for each phase throughout single development projects, which were reviewed in six milestone decision meetings identified as M0 through M6. The general phase model is illustrated in Figure 61.

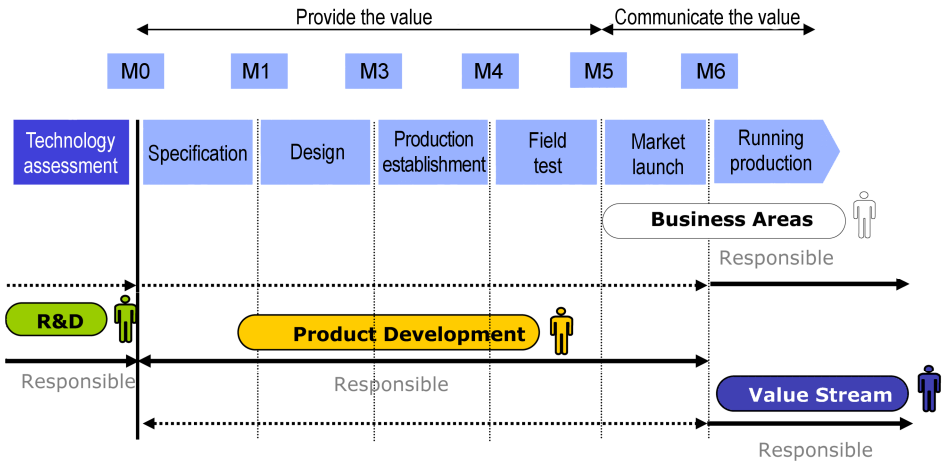


Figure 61: Simplified phase model for product development projects of DE.

In the lower part of Figure 61 the responsibilities of for the different development phases were represented. Obviously the project model was set up for the support of physical/hardware products, both in terms of the main phase tasks as well as through the organisation of the DE development departments, which were focused on hard- and software engineering competences.

Prior of the M0 project start a three phases front-end process was defined in order to stabilise the generation of ideas, the evaluation and prioritisation of project proposals and to ensure the feasibility of projects prior to their initiation. The front-end innovation process was standardised across all the divisions of the Danfoss enterprise, in order to ease cross divisional learning and optimisation of processes. The cross-enterprise standardisation of product development processes was planned to be expanded to the actual development project execution models (such as the one in Figure 61), a development which was in its preparation during the case study period.

The preparation phases before M0 are there to ensure that when we pass M0 or to the latest at M1 we know precisely what we want to achieve, and we also know what we are capable of. The assessment phases were amongst other reasons invented after we had to terminate a major project between M3 and M5 because we realised we wouldn't be capable of putting the product in full scale production.

Control Engineering and Applications Manager, DE

The front-end process was separated from the project execution in terms of both time and team setup. A simplified model of the process model is shown in Figure 62.

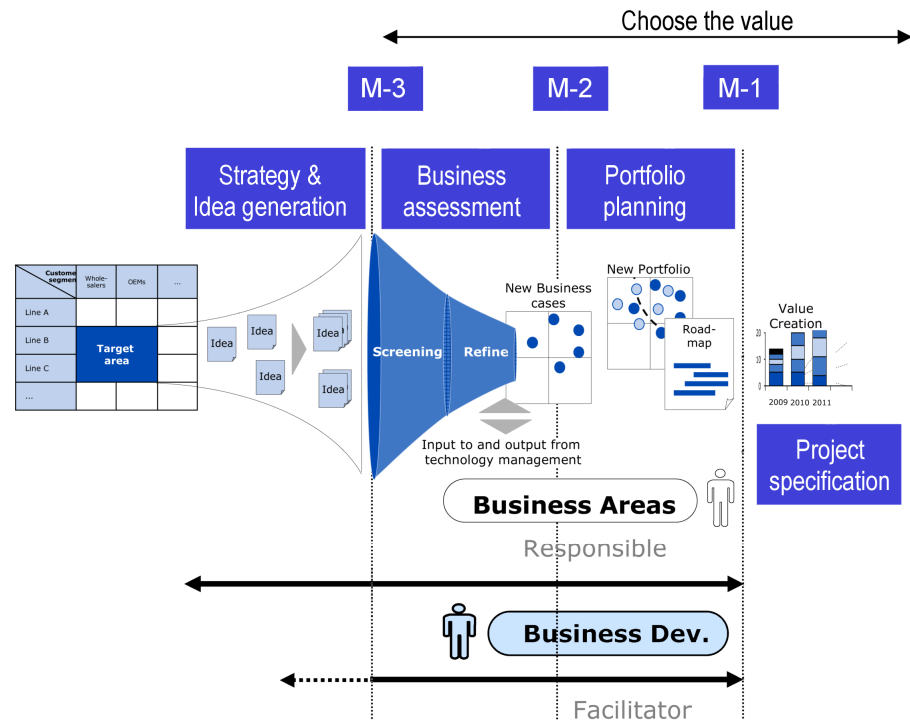


Figure 62: Simplified process model for the conceptualisation of new products and offers within Danfoss. Adapted from Danfoss material.

The sales organisation *Business Areas* were responsible for the generation of product and technology ideas. In a process facilitated by the DE *business development* group, these ideas were then assessed in two rounds through a general filtering of ideas regarding their fit to the strategic plans and the existing product portfolio, followed by an assessment of the business case and expected technological challenge. If the technological challenge was evaluated as too high to ensure a smooth execution of the actual product development project, the technology development tasks were separated into a number of technology development projects prior to the product development project execution. By doing so the risk level of the product development projects were reduced to an acceptable level and troublesome project terminations in later stages were prevented. The final result of the front-end process execution was the inclusion of the highest prioritised project proposals into the product development portfolio of DE, while identified technological opportunities were transferred to the relevant research groups (both within DE and in other Danfoss departments) in the assessment phase prior to the M-2 review meeting.

The front-end process effectively served to ensure both breadth and depth in the conceptualisation of new products for the DE department, while minimising risk factors in the execution projects (cp. Figure 61). While the project portfolio and roadmap was reviewed at least twice every year, the idea generation process was only initiated episodically, based on DE & FR managements decision cycles in focusing on specifically selected technologies, customer segments or application areas. As a general rule, the idea generation and assessment processes were meant to be executed twice every year, to generate input for the roadmap review meetings, although

this depended on the number of independently emerging project proposals and the resources available for conceptualisation tasks.

While the front-end process clearly could be utilised for the generation of service oriented offer proposals (depending on the defined focus area), the process was always facilitated and owned by a hardware development organisation. The exchange linking to possible service oriented development organisations (such as there could have been established within RETAIL-CARE™) was relatively weak, especially as this most likely would imply exchange of the team responsible for the assessment preparation.

The front-end process was also restricted from focusing on issues regarding revenue mechanisms or the conceptualisation of general business model changes, which was defined as a senior management task and out of the scope of product development processes. This delimitation is underlined by the quote below.

In the execution of front-end process projects we do not work on business model development; that is simply out of scope. The process is strictly invented for product development preparation.

Director of Concept, Danfoss business support

The DE development system, while capable of efficiently developing hardware controls, was not set up for the development of service offers. The process models guiding the development projects were optimised for technology driven mass manufacturing projects and consequently the organisational competence was focused on manufacturing and product technology. These properties were not matching the requirements of service development as it was perceived in the RETAIL-CARE™ departments:

The front-end process is a fantastic process, but also extremely slow and rigorous. It is designed for major manufacturing and development efforts, [where] there is an element that is very structured and needs to be, and we are participating in part of this. This could be the development of COP [coefficient of performance] calculation algorithms, which go through a number of phases and then are ready for the market in Q3 or Q4 of the following year.

But then there are certain market requirements and responses from customers that we get, that we have to respond to promptly. There is a base platform that you want to introduce enhancements to in a structured and rigorous way, and that will be available broadly to all customers. And then there are custom works that still need structure and documentation, but which don't go into a massive development process.

Director, RETAIL-CARE™

RETAIL-CARE™ targeted the most key strategic customers and build customised agreements with these based on RETAIL-CARE™s competences available within operations management, engineering, project management and training, supported by the monitoring IT-infrastructure. All elements were developed incrementally, based on the specific customer requirements which were renegotiated on a project to project basis.

In order to secure a large or long term customer contracts the assigned project team works on a dedicated solution for that specific customer – which is where we spend most of our time.

Director, RETAIL-CARE™

The service business was thus based on an entrepreneurial model, where RETAIL-CARE™ reacted to the explicit requirements of one customer, developed a specific solution to fulfil the negotiated agreement and then evaluated the general applicability of that specific solution. If the solution was found to be valuable in general, it was attempted turned into a standard element in the baseline offer portfolio. According to the director of RETAIL-CARE™, the department did not use time and resources on long term developments, but rather focused on the needs of the identified and targeted customers.

The main customisation tasks regarding standard services like e.g. alarm handling or performance reporting regarded the integration of multiple stores into the IT-infrastructure system, as the quote below describes.

A customer might have 500 stores, and in those 500 stores he likely has 7-8 different brands of controllers, some of which are 20 years old. There is no standard solution to bring together the data from multiple stores in a value giving way.

Director, RETAIL-CARE™

In a customer relationship as the one indicated above, obviously a vast number of single installations each in individual product life phases influenced the interactions between Danfoss and the customer. RETAIL-CARE™ therefore initially offered the customer value through the integration between legacy installations, followed by an analysis of possible beneficial retrofit projects across the enterprise. In the process of that analysis, RETAIL-CARE™ emphasised the quality parameters of Danfoss equipment and underlined the synergy effects obtainable by combining e.g. RETAIL-CARE™ remote control services with Danfoss controllers. RETAIL-CARE™ in this way combined the options of direct service support to the customer, regardless of their legacy systems, with the option of generating stable sales volumes of retrofit installations, primarily using Danfoss components.

This strategy of covering the existing product base of other vendors by the RETAIL-CARE™ services, while promoting a gradual shift to Danfoss controlled systems, required that there was a significant difference in supportability of Danfoss installations compared to other controller brands. This was the main reason for driving a closer collaborative development effort between RETAIL-CARE™ and the DE development department.

Yes, we can deliver some value from a competitors system, but from a Danfoss system we should be able to receive and deliver on a much higher level on the services side. There isn't a significant difference yet, but there should be.

Director, RETAIL-CARE™

In conclusion, the development function of the RA division was clearly oriented towards a general business model of efficient manufacturing, and the subsequent sale of hardware products. In contrast, the development function in the customer oriented service departments was based on con-

tracted development projects for individual customers. The transfer of customer specific solutions to the general offer portfolio was done episodically and based on the individual solutions general applicability and potential.

8.7 Interpretation and conclusions

The case of Danfoss' RETAIL-CARE™ represented a PSS based primarily on the communication functionalities of Danfoss electronic controllers, combined with a dedicated customer activity support delivered by the engineering teams of the RETAIL-CARE™ department. The main driver for customers seemed to be the ability of RETAIL-CARE™ to manage the existing store sites' refrigeration system monitoring regardless of the installed equipment's types and brands, while gradually aligning the technology level of systems through retrofit projects. Secondly, RETAIL-CARE™'s monitoring systems enabled gradually increased remote control of store sites and a continuous energy management, ensuring lowest possible energy consumption, which for many customers amounted to large fractions of their stores operational expenses.

Generally, the RETAIL-CARE™ business concept and included services seemed to have grown out of a key account sales management approach. Many of RETAIL-CARE™'s service offers existed prior to RETAIL-CARE™, e.g. customer training, technical support etc. Implemented within the frame of the service contract business, these services were moved from a sales supporting function in the company, to a revenue generating activity for the customers approached by RETAIL-CARE™. The engineering capacity and competences, which earlier supported customers in ensuring the quality of system designs in order to secure component sales, have been utilised to actually execute the system design projects themselves through RETAIL-CARE™.

8.7.1 The constitution of the Danfoss PSS

Analysing the PSS activities, a number of defining properties became apparent, which are summarised in the following paragraphs:

Focused customer segment

The PSS was targeted narrowly on a small number of strategic key account customers in the FR market. The main reason was found to be that contract and task negotiation and the integration of new customers' store sites' systems into the IT-infrastructure were the main activities related to new customer relationships. As the resources necessary for those tasks were relatively independent from the customer enterprise size, larger customers inherently were the most profitable.

Business area in the support of defined customers regarding technology development and operation

The PSS effectively supported the activity sequences of a narrowly defined profitable customer group, namely the technical management of large FR enterprises. This support was based on life cycle knowledge of a technology field, namely retail refrigeration systems. Crossing life cycle systems, such as the food stored in the monitored systems, were utilised in delivering value to the customer group, e.g. by the automatic generation of food quality reports.

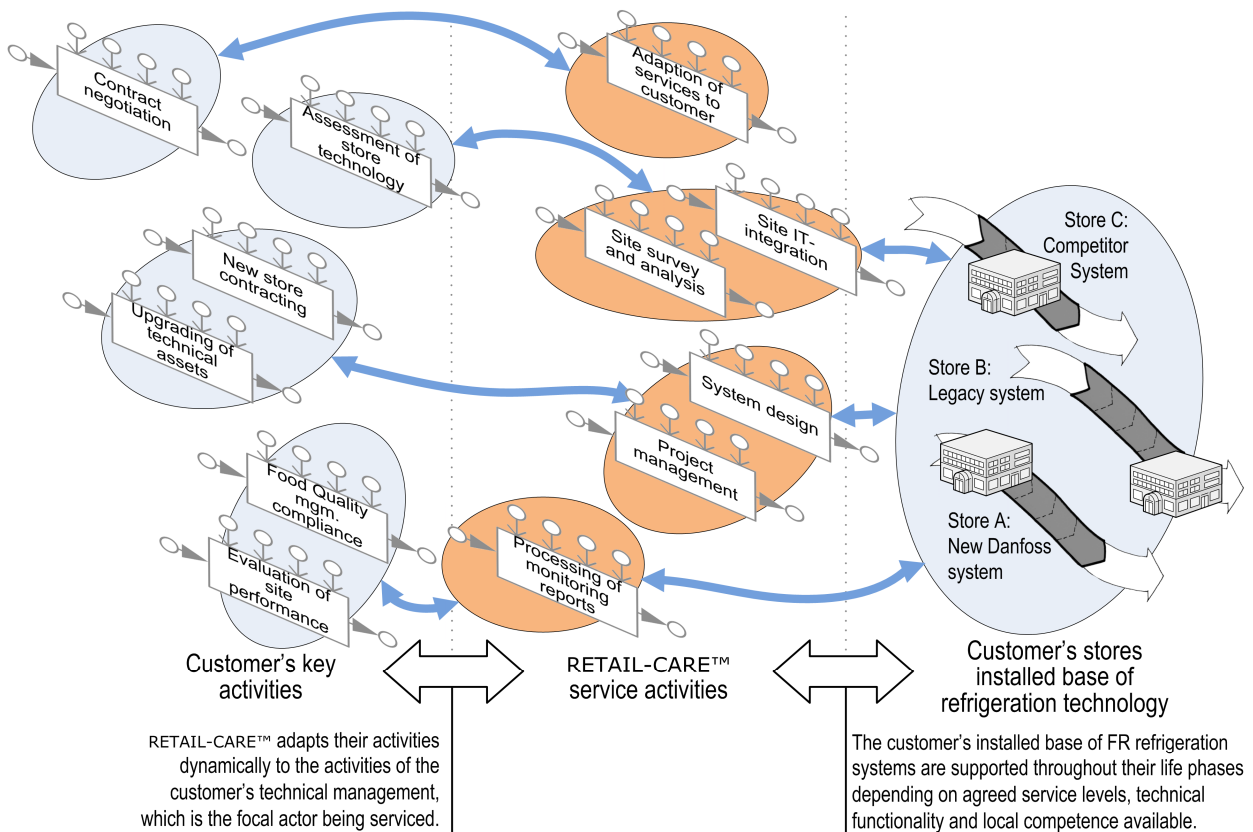


Figure 63: RETAIL-CARE™ linking the customer's stores installed base to the tasks and activities of the enterprise technical management.

Figure 63 illustrates how the service offers of RETAIL-CARE™ linked the various activities of the RETAIL-CARE™ customers (the technical management of large FR enterprises) to the installed base of refrigeration systems in the enterprises real estate. Regardless of the type and age of the installed systems, RETAIL-CARE™ collected accessible performance and food quality related data and compiled it into reports informing the main customers as well as their employees (e.g. through store performance reports) and actor networks (such as food administration authorities).

While the activity sequences were not following a fixed sequential order, the RETAIL-CARE™ team assigned to manage the continued relationship with the individual customer assured that RETAIL-CARE™ could deliver a range of engineering services e.g. when new stores were to be equipped. Since RETAIL-CARE™ managed the performance monitoring of the customers stores, opportunities of retrofit contracting projects could be anticipated and even negotiated actively based on the existing performance data.

The initial tasks relating to newly secured customer contracts were the integration of the existing legacy equipment into the agreed-upon performance and food quality management monitoring standards. Most other customer activities were based on the RETAIL-CARE™ employees' professional competences, which were applied through engineering and other projects negotiated within the framework of the customer relationship. The resource needs associated with single contracts thus were high in the initial integra-

Crossing lifecycle systems

tion phase, followed by fluctuating demands depending on the customers investment needs. RETAIL-CARE™'s main source of activity was the delivery of engineering and project management services regarding the necessary retrofit and upgrading of customers legacy store base and the occasional expansion through new building of stores.

Exploring other activity areas of the customer, RETAIL-CARE™ broadened services towards related product technologies, such as lighting and HVAC controls, which largely compare to refrigeration systems regarding their technical management requirements. Figure 64 illustrates the path of development broadening the scope of technical installations covered by RETAIL-CARE™ services. This was seemingly based on the identification of the chosen customers other activities and tasks, namely the general technical management of FR-chain energy using assets. This development represents how RETAIL-CARE™ by monitoring and analysing the responsibilities and activity sequence of their customers identified related crossing product life cycles, in this case those of HVAC and lighting controls.

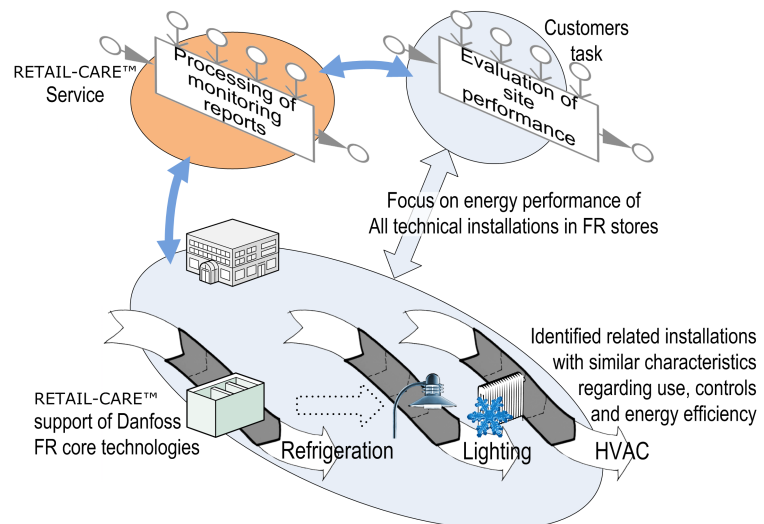


Figure 64: Diversification of service offers - and supporting controls, due to identified related and synergetic needs of the customer.

In effect, the insights gathered in the service delivery business fed back to the development of new types of controls, which included lighting and HVAC automation and remote control functionality. Although developed largely separate from the RETAIL-CARE™ organisation, DE attempted to match the needs of identified customers requesting integrated remote control of all technical assets in e.g. convenience stores.

Primary activity related to system design and implied components sales

While the monitoring, remote control and fault detection functionalities of Danfoss controllers were obviously supporting the performance of the RETAIL-CARE™ system, the IT-infrastructure system's challenge was the retrieval and analysis of data from legacy and third party systems, not the integration of new controller setups. The mixture of different control systems installed with most customers also hindered proactive service support covering all connected stores, as the necessary controller hardware was simply not installed.

Highly localisation of services through building of local human capacity

While the monitoring IT-infrastructure was largely independent from local context and could be applied virtually unaltered on a global scale, the technical support and training activities were highly localised due to market maturity, employee competences and business structures. Thus the main development focus of RETAIL-CARE™ was not the development of a standardised service portfolio, but the gradual growth and operational adaption market by market.

Dependencies between component and service supplier underlined need for product and service integration

Although the services of RETAIL-CARE™ were generating profits in themselves, the option of generating controls component sales through the engineering service channel was obvious. To support the trustworthiness of selling Danfoss components, RETAIL-CARE™ needed to establish a continuously improving performance synergy between Danfoss component functionalities and RETAIL-CARE™ service performance.

8.7.2 Development system and activities

The RETAIL-CARE™ and DE departments took very different approaches to the development of their offers. This was partly due to the departments' object of design being of either process or product character respectively, but also resulted from the two departments' historical path defining their understanding regarding the options of increasing value through either entrepreneurial growth or superior functional solutions.

Customer driven development incrementally enlarging service baseline portfolio

The development of new services in RETAIL-CARE™ was based on negotiations with single customers. Based on a baseline of existing services, single customers' requirements were turned into goal specifications and then implemented through focused engineering projects. This approach, which resembles the literature discussed in 0, ensured that development activities were always financed by existing customers and no development investments were lost. Conversely development was always based on existing baseline technologies and customer segments, making diversification into new market segments or offering types unlikely. Also internal rationalisation of processes through development projects was made less likely, as the internal delivery systems were not in focus in relation to customer negotiations.

Product development process model set up for industrial manufacturing

The DE development system, while capable of efficiently developing hardware controls, was not set up for the development of service offers. The process models guiding the development projects were optimised for technology driven mass manufacturing projects. The model in Figure 61, which in the company was supported by detailed checklists regarding the different phases' main tasks and deliverables for review meetings contained only tasks and deliverables relevant for product development (e.g. HW design documentation, critical component ordering checklists). The development of adapted services in RETAIL-CARE™ was based on quick implementation of a prototype setup, followed up by evaluation and standardisation for consecutive application of the service in other customer relationships. On the contrary, the development model of DE exhibited the industrial approach of establishing a production system capable of mass production before the product was to be released to customers.

Regarding the professional development competence in the DE department, also here the focus naturally was on product related technology, processes and production preparation. In conclusion, the existing approach

Ownership of processes and concepts
implies development focus

of DE to product development was not suitable for the development of services in its structural setup.

While the generic idea generation framework process applied in DE (cp. Figure 62) could be utilised for the generation of service oriented offer proposals (depending on the defined focus area), the process was facilitated and owned by the DE organisation (and other manufacturing departments throughout the Danfoss enterprise). It was never applied by e.g. RETAIL-CARE™, which was assumed to possess the service oriented competences of setting up delivery networks and structuring service interactions. The more detailed process plans within the front-end framework were, just like the ones in the DE project process model, also aligned with the tasks of conceptualising and assessing manufacturing products, but the model management departments within Danfoss were at the time of the case study considering how the front-end process might be adapted to the needs of service development.

The strongest barrier to the use of the front-end process for conceptualisation of service offers seemed to be the organisational ownership and responsibility for the process. As DE's R&D group was responsible for structuring the project portfolio and roadmap for the FR controls related front-end processes, service offer developments would naturally be prioritised low, none the least due to the missing necessary competences in the DE organisation. In theory, service oriented concepts could have been transferred to a possible service oriented development organisation (such as there could have been established within RETAIL-CARE™), but even if such a development group had existed, the barriers to successful transfer were strong, since it most likely would imply an exchange of the team responsible for the assessment preparation and later execution.

At the time of the study, the RETAIL-CARE™ activities were focused on a narrow segment of customers, mainly defined by their size and position as strategic key account customers. The initial service portfolio of RETAIL-CARE™ was developed through close collaboration with the first strategic customers, and the further development was approached in a similar manner with new customers. Although this approach yielded good results in terms of adapting the evolving service portfolio to a geographic growth strategy, it seems unlikely that new customer segments or applications could be explored effectively using this approach. Also the collaborative alignment of controls and services development, which was explicitly asked for by the respondents, was not supported by the development approach of RETAIL-CARE™.

It seems that a collaborative front-end approach, resulting in separate project portfolios for dedicated development groups could be utilised to create innovative product service combinations, both diversifying offers for the few existing customer segments, but also creating solution models for other segments.

Other main properties of the Danfoss development function are the combination of a stepwise technology driven development (DE) and a more fast paced customer driven matching of individual needs (RETAIL-CARE™). The technology departments were creating an increasingly open technology architectural frame that subsequently and continuously was filled with customer oriented utilisation functionality. This filling of the technology

framework was based on implementation oriented development projects, initiated by the explicit requirements of individual customers.

9 Modelling service oriented business

In this chapter the application of the modelling schemes proposed in Chapter 3 are analysed in order to answer the first research question of the project: Can the key activities in the life cycle of a defined product/service-system be identified and analysed through the modelling of life phases and their use processes?

Building on the theoretical work of McAloone and Andreasen [2002; 2004], a PSS approach to business creation is proposed as a way for manufacturers to proactively influence and support the service life of their products. This active influence and support is effectuated by the offering of integrated solutions of products and product life supporting services. As postulated in chapter 3, an approach to identifying service activities throughout the product life is the systematic modelling of process sequences between product, provider and customer.

Using the TrS model of Hubka and Eder [1988] as template for the modelling of single *service delivery* activities, the basic model for the representation of *service delivery* in abstract terms is the *parallel transformation system model* (PTrS) illustrated in Figure 39. Through the application of this modelling scheme in the three industrial cases, the applicability of the model for the description of operational support for service life phases of technical systems was tested.

9.1 Modelling single service activities

First the applicability of the model for the description of a service delivery activity is analysed, using one of the product related service support activities from the Danfoss case as an example.

An example of proactive service life support

Utilising the delivery capacity of RETAIL-CARE™, Danfoss took responsibility of its products' service life activity of performance monitoring. The company released the serviced FR store employees from the task of checking temperatures and other set points of the refrigeration system, and instead enabled the control components to transmit the data necessary for system supervision back to the RETAIL-CARE™ monitoring sites.

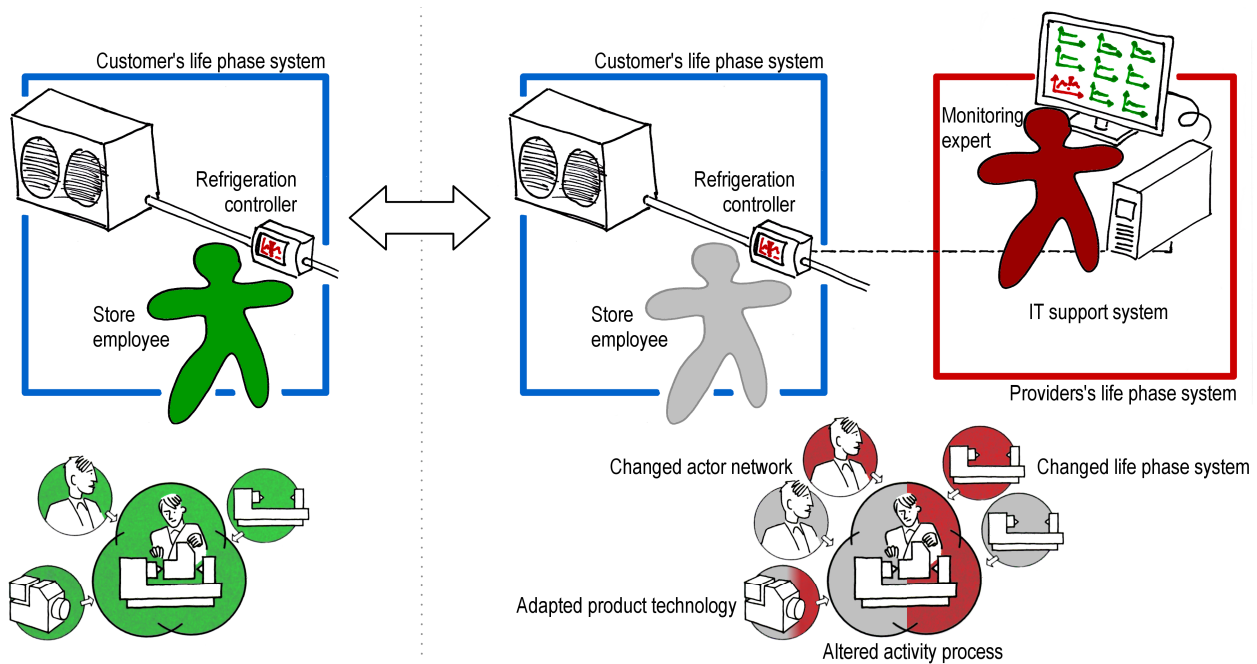


Figure 65: Unsupported life phase activity on the left, supported life phase activity on the right (cp. Figure 21).

Figure 65 illustrates the differences between the unsupported service life activity and a service life activity supported by RETAIL-CARE™, by a thought service incident example. On the left side of the figure, the store employee is responsible for evaluating the display of the refrigeration controller and decides how to react to an alarm indicator. On the right side the controller is connected to a centralised monitoring site, operated by RETAIL-CARE™. The alarm is handled by monitoring experts who decide to switch the controller into an emergency control state by remote control and commission a maintenance technician visit on site within two working days. The technician is supplied with information regarding the error code and possible causes of the encountered failure. The store employee is relieved of the responsibility of changing the system configuration, but is warned of the currently reduced refrigeration capacity.

The diagrams (cp. Figure 21) in the lower part of Figure 65 indicate in what respects the life phase activity has been changed:

- **The life phase system is changed**, as the on-site control system is extended with a centralised monitoring and data logging facility (connected by internet infrastructure). In effect a parallel support life phase system has been established.
- **The activity process is altered**, as the alarm signal is transferred to the parallel support system, and the store employee is relieved of monitoring the system state on site.
- **The actor network is changed**, as the responsibility of handling the situation is transferred to the support site and the ordering of technical assistance is done from the support site instead of by the store employee.

- **The product** (refrigeration system controller) **has been adapted** to enable remote control operation. Additional products (both hard- and software) have been added, some of them specifically developed for the monitoring support system.

The changed operational pattern reduces risks of food loss for the FR store, as alarms are handled instantly, relieves the store employees from monitoring duties and allows for quicker repair as maintenance servicemen are better informed of possible failure modes. In return, the monitoring service is rewarded alarm handling fees.

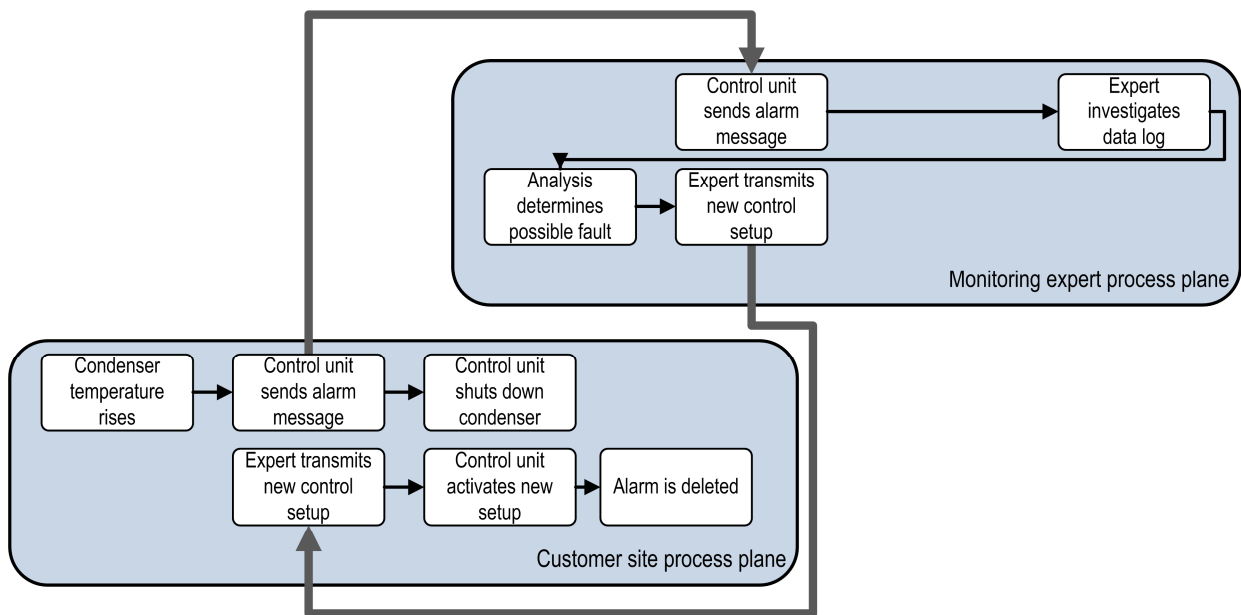


Figure 66: A process flow representation of the service activity of Figure 65 using the PTrS model template (simplified).

Modelling of processes and resources needed for specific activity

The model in Figure 66 illustrates how the parallel activities of three institutional actors are linked by the process flow of the alarm handling incident. The three levels clearly divide the partial process responsibilities of the involved actors. In a second step, the resources (operators) necessary for the process completion are linked to the processes. The process-resource links are illustrated in Figure 67.

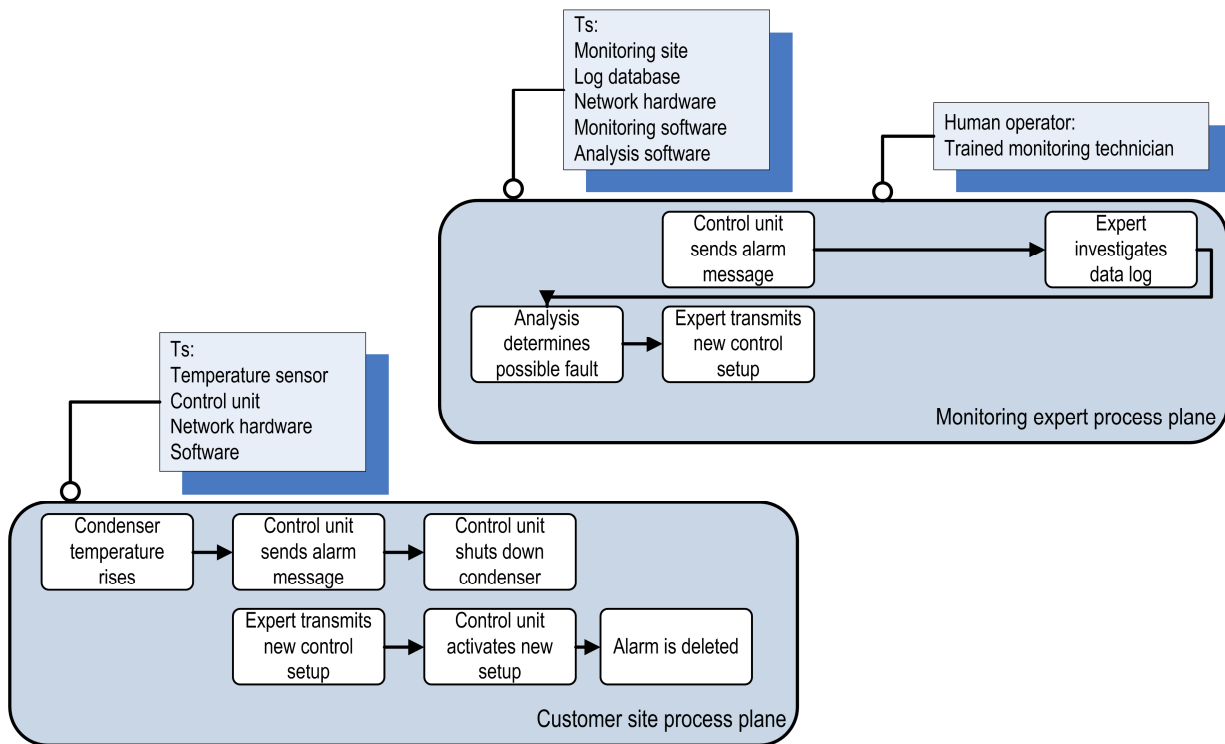


Figure 67: Linking processes and resources for the service activity of Figure 65 using the PTrS model template (simplified).

In Figure 66 and Figure 67 the processes and resources linked to the specific activity are modelled. The process model (Figure 66) identifies the process steps and which processes require communication or collaboration between actors or systems, while the model in Figure 67 completes the transformational model through the identification of necessary delivery competence and technical systems. This second step can aid the definition of requirements to technical systems (e.g. communication abilities of the controller, resource planning support etc.), human operators (availability, competence), information (necessary integration between actors, data sources and management) and management (planning, agreements regarding responsibilities). In effect the first step of the process modelling identifies the distribution of activities between the involved actors, while the second step identifies the artefacts and resources necessary for execution of the modelled service processes. While processes and necessary resources are readily modelled, the relationships between the actors taking part in the activity are only implicitly defined through the visualisation of the process steps and employed resources.

Restrictions and application scope of the PTrS model

The example of Figure 65 represents a single instant of one of the service delivery processes in the RETAIL-CARE™ business. Although this particular activity directly creates value for provider, receiver and associated actors (e.g. the maintenance service company), the activity must also be seen in relation to other activities in the PSS as it can contribute to value creation in other processes. In the example, performance data of single stores gathered by RETAIL-CARE™ allows the generation of accurate accounts of the customer's stores energy performance and could allow RETAIL-CARE™ to propose retrofit programmes including concrete performance and financial

key figures for proposed investments. All of these related activities are outside the scope of the process modelled in the example, and the model itself is not contributing to the identification of these options of beneficially linking activities in the PSS.

This underlines how the PTrS model's primary application is the modelling of single processes, where focus is on the definition of process steps, the concrete division of responsibility and the identification of necessary resources for the process execution. The process model is not suitable for the integrate modelling of multiple interactions such as several operation activities for the example above. Also the prolonged utilisation of products, where process execution and resources are altered through time due to experience, wear etc. is not suitable for modelling using the PTrS, since the division between operands and operators becomes blurred and also in- and outputs are becoming less well defined.

The application of the PTrS to model the concrete process steps for selected activities in the relationship between product, customer and provider is differing significantly from the traditionally advised application of the original transformational model in literature (e.g. [Hubka and Eder 1996]), where the model is primarily used to represent the primary use functionality of the product under consideration (e.g. the refrigeration of retail goods in the example above) and other use activities are regarded as sub models in a hierarchy of nested models, if they are considered.

9.2 Modelling exchanges and benefits

The PTrS model describes a single stabilised process out of the many different activities taking place throughout the products service life. For the modelling of the exchanges between the actors participating in a PSS on the longer term, a different approach must be taken, where the single process is not detailed and instead the accumulating flows of money, utility and information are accounted for. This can be accomplished through the creation of graphical actor network models. The modelling of actor networks, such as described by Donaldson et al. [2006] and exemplified in Figure 55, accumulate the exchanges between actors through a long sequence of activities.

9.3 Linking service processes

Linking modelled processes

Tan et al. [Tan et al. 2006] describe two important life cycle dimensions that must be considered in service oriented product development, the *product life cycle dimension* and the *customer relationship life cycle dimension* (cp. Figure 41). Both can be represented as a chronological sequence of processes when typecast and stabilised to enable their modelling.

For physical technical systems, Olesen [1992] illustrates this progression in theory by the score model in Figure 20. In relation to the modelling of activities in the customer relationship, there is not necessarily a clearly defined life cycle progression identifiable that can be used to structure the modelling efforts. However, the CAC model introduced by Vandermerwe [1993] suggests that customers' needs develop in a cyclic manner alternating between need identification and the acquiring of solution products or services.

As shown in the previous section, the PTrS modelling scheme can be used to represent partial sequences of linked processes in a products service life. In theory, the sequence of identifiable life phase activities can be modelled by a corresponding sequence of PTrS for a precise description of process steps and necessary resources. While the attempt of a complete modelling of all processes in the case studies were evaluated too complex for any practical applicability, selected key processes can be modelled and linked by a more general modelling of the products life phases and the governing actor networks as proposed by Tan et al. [2006]

9.3.1 Product life cycle based modelling

The product based life cycle understanding is based directly on Olesens theory of dispositions [Olesen 1992]. While the products in the PSS pass through their individual life cycles, a sequence of different activities will be performed. In the Novenco case study, this approach was followed in order to identify the key use processes of FF installations and reveal how the components and system design was matching the requirements arising throughout the product life cycle.

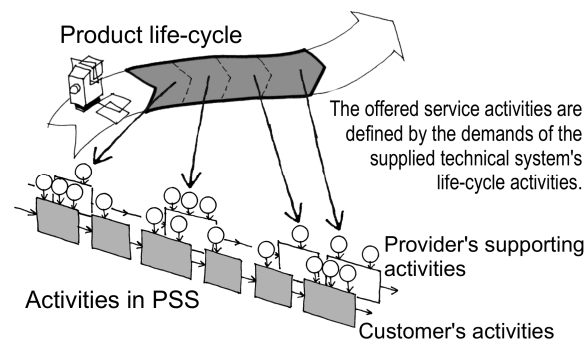


Figure 68: PSS activities supporting life cycle of supplied good [Matzen and Andreassen 2006].

Figure 68 illustrates the line of reasoning in this approach. The curved arrow represents the expected life cycle phases of the product, such as a FF system in the Novenco case study. Based on an identification of expected life cycle activities, the provider develops a palette of supporting offers, which are operated in parallel to and assist the customer's activities throughout the products service time. The sequence of performed activities involving the customer, the provider and the supplied product is illustrated by the sequence of parallel transformation processes (cp. Figure 39) shown in the lower part of the figure.

In the case study, the main product life phases of a stereotyped FF installation formed the basis of the analysis. Although the general phase sequence from sales, contracting, installation, test and operation to maintenance and liquidation was relatively fixed for all installations, the identification of main activities on the next detailed level proved a complex task. Depending on the system type and size as well as the customer type and location the precise process sequence varied significantly. Apart from the differences between different system types and installations, the respondents in the company had only limited insights in the actual operation life phases of their products. The service life phases were primarily controlled by the cus-

Modelling is difficult both due to product life variations and lack of knowledge in the company

Modelling improving the understanding of dispositional effects between company activities

tomers, and their experiences were only seldom fed back to technical managers at Novenco, making it difficult to design servicing systems. Finally, even for long living investment goods like the FF systems analysed in the case study, the single instantiation life cycles vary considerably depending on the customer's usage patterns and their approach taken to the maintenance of technical systems.

For the respondents in the company, the results were twofold.

Firstly, the attempt of modelling of the product lifecycle, including the detailed investigation of single processes through the application of the PTrS model helped to identify how components, system design and the existing contracting processes influenced the serviceability of the resulting system instantiations in the operation life phases.

For long living investment goods (such as the technologies studied here) and presumably most types of products, the specific life cycle of single product instantiations will never exactly follow the sequence of processes modelled in a product life model as illustrated in Figure 68. Most system instantiations will be going through a number of upgrades, maintenance cycles and ownership changes, making the prediction of specific support needs difficult. Usage and wear patterns of every instantiation are in effect unique, just as the method of disposal may vary significantly between instantiations of the same product. Therefore the modelling of the product life cycle must include the consideration of possible alternative routes to ensure a sufficient robustness of the resulting model.

Modelling creating a language to communicate service concepts and their implications for the company

Secondly, product life modelling helped to create a rich picture of the possible activities that could be supported through service offers of Novenco. In this respect it also helped to identify the knowledge gaps the organisation needed to investigate in order to evaluate the feasibility and profitability of the identified service activities.

For development purposes the product life model serves to create a virtual prototype of the service system. The model can be utilised to predict the effects of dispositions taken both during the development of components (e.g. FF spray nozzles) and configuration of the service system applied to various life phases (e.g. the contracting process or current approach to spare parts sales). The emphasis is put on the use properties of the product, and the co-development of product and life phase systems. The modelling of the complete product life and definition of as many independent use related processes as possible prompts the development team to decide which use activities beneficially can be supported, both for reasons of optimising the use performance, and to support business for the provider. In the Novenco case, the company respondents experienced that product life modelling can be utilised to visualise both the companies and the customers' tasks and responsibilities and thus creates a language for improved alignment between the different professions and departments in the company in order to optimise delivery effectiveness.

Regarding the analysed fire fighting technology the case study revealed that the company actually was not aware of, whether their customers actually followed the inspection and preventive maintenance requirements set by both Novenco and regulation authorities. The spare parts sales volume indicated that a considerable proportion of customers did not exchange components as required, resulting in both reduced safety levels onboard

and reduced spare part turnover. If design data regarding the individual system configurations could be shared internally in the company between the contracting and after-sales departments, the after-sales business could utilise the knowledge of the customers systems configuration and inspection requirements in a proactive after-sales service approach in order to effectively improve the system operational performance and after-sales business turnover.

In the Acta case, the company had already started the transfer of information originating in the contracting processes and transferred spares and wear parts listings for individual crane systems to the inspection service system's prototype database. Although manually transferred and in a prototype implementation phase, the knowledge sharing effects pointed to opportunities of a more offensive after-sales approach for the benefits of both customers and the company.

9.3.2 Customer relationship life cycle based modelling

For many PSS providers, the strategic intent of PSS provision is to support the customer in his utilisation of the provider's core technology, and thus the continuous support relationship is of much higher importance compared to the life span of the utilised products or systems. This was certainly the approach taken in the RETAIL-CARE™ system, where the customer group was restricted to companies with many hundred single installations in varying life cycle phases.

In this type of business model, the relationship must be maintained across the changing product generations and the provider must align his approach and operations to match the development of the customer's needs. The focal object of development in this case will often be the seamless integration between products and service systems towards the customer, as opposed to the optimisation of utilisation processes of the product itself.

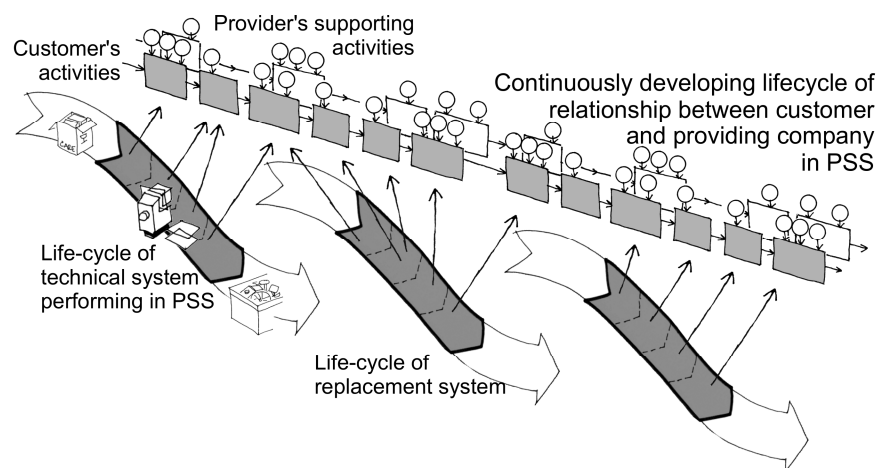


Figure 69: PSS life cycle of customer relationship [Matzen and Andreassen 2006].

In Figure 69 the continued relationship between customer and provider is sketched. Throughout the developing relationship, several products are delivered to the customer and supported throughout their individual life cycles. The relationship covers a longer period in the time domain compared

to the single product's life cycle of Figure 68. Consequently the customer's sequence of supported activities becomes the focal point of the supplier interest. Due to the regular interaction associated with the customer's activities, the supplier gains insight in the developing needs of the customer and the operational state and condition of the utilised products. The provider can anticipate and act accordingly to the changing needs of the customer.

In the RETAIL-CARE™ case study, the support of single installations by the alarm handling system – which represents a product life related service offer, was largely independent from the consultancy services regarding retrofits and new building of stores. The operation monitoring and alarm handling services were the entry point to building a long term relationship with key customers, but gathered operational data was not necessarily used in the negotiation of other service contracts.

In conclusion, the service portfolio in the RETAIL-CARE™ case targeted activities and responsibilities on many different levels in the customer organisation, ranging from technical operation of single refrigeration systems to consultancy services regarding management strategies for the general management of technical assets across the complete customer enterprise. This implies that the customer relationship life cycle in systems of the character as operated by RETAIL-CARE™ are progressing largely independent from the single installations' life cycles.

9.4 A partnership based business model

The creation of a long lasting relationship between service supplier and customer requires the gradual alignment of operational processes. In the Danfoss PSS, customer relationships were built on the gradual introduction of service offers towards different parts of the customer organisation, focusing on key customers. In the Acta case, the initial offer of safety inspections led to later service contracts regarding overhaul or retrofits of related equipment technologies. For PSS in the industrial context of this research, it means that the single customer relationship originates from the technology related support services, but later is broadened depending on the providers' competences and readiness of delivering services directed towards the longer term development of the customers' business.

Depending on the type of services, and the dependency relations between the two partners, the alignment might be more explicit on either the supplier or the customer side.

Figure 70 illustrates the gradual expansion of the delivery focus from the delivered product to a broader technology support. On the operational level, the service supplier takes over some of the operations earlier executed by the customer's staff. This leads to a gradual dispositional alignment, as the customer can adapt his organisation to the changed responsibility distribution and the provider can optimise his products to fit his own delivery network. Finally, the customer and provider can choose to enter into a strategic partnership, in which the customer relies on the technology expertise of the provider, while the provider is benefiting from a reduced competitive pressure.

Finally the customer may be considered a partner in the delivery network of the whole PSS focusing on the utilisation of the delivered technology. In

this context, PSS may be regarded a long term business strategy based on value co-production amongst partners.

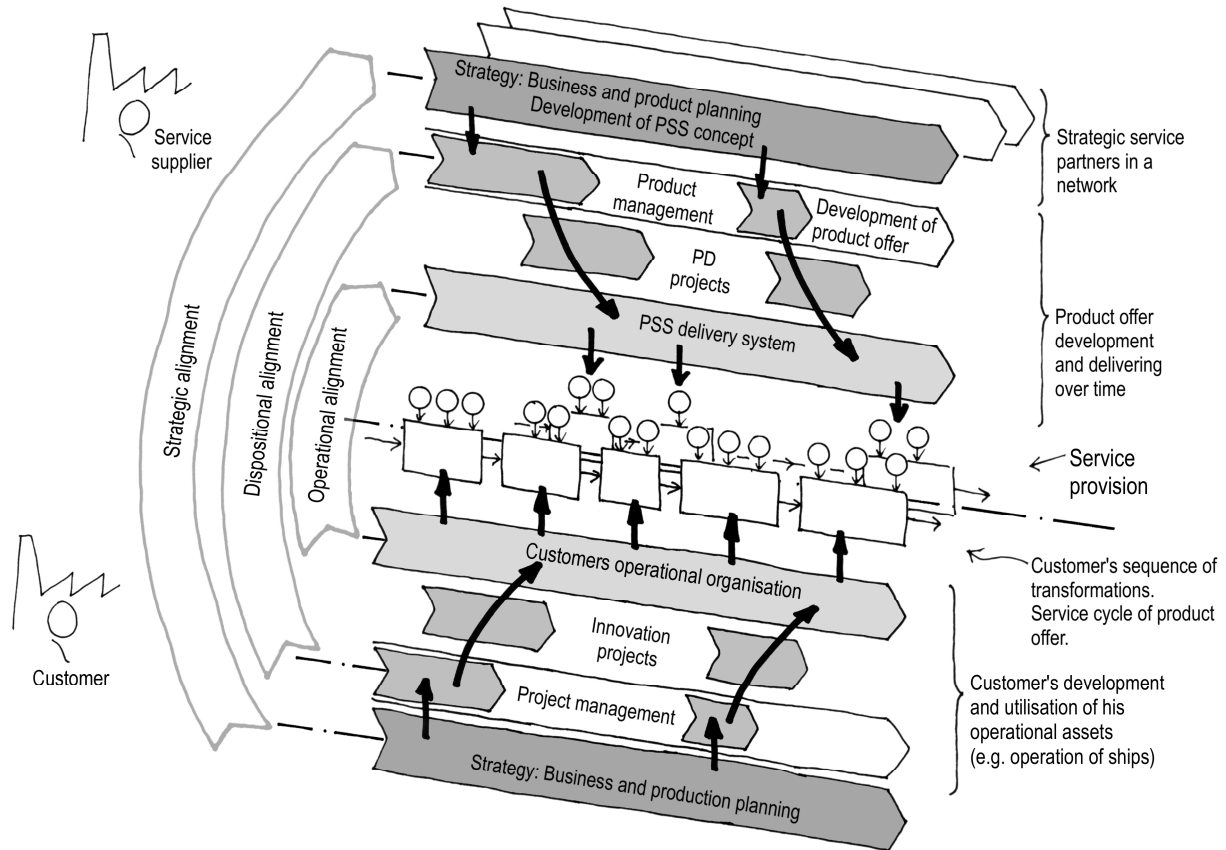


Figure 70: Gradual alignment of business processes, based on the provider's technology expertise. Adapted from [Matzen et al. 2005].

For the modelling of activities in product development the gradual intensification of customer relationships especially with key customers represents a challenging field of opportunities. While the product life cycle and the closely related use processes are relatively unambiguous, the management processes of customers vary considerably, and the prediction and development of service elements that can be transferred between customers and be efficiently delivered by the provider network is not trivial.

In the Danfoss case, the offer development was based on a key account management approach as described by e.g. Foote et al. [2001]. Here the assigned customer team is drawing resources from the service organisation according to the current tasks, and the development focus is to continuously matching the resource pool to the competence needed by customers.

9.5 Conclusions regarding life cycle modelling

The parallel transformational system model has proved applicable to the modelling of identified single operational processes. The model can be used to describe process steps, denote necessary resources and competence and show the responsibility division between the actors involved in the processes. To create a more comprehensive view of the dependencies between single processes, the dispositional effects throughout the products service life and the relationship between customer and provider, the single process models must be linked along two different life cycle systems:

1. The product life cycle from system design, manufacture and use to liquidation
2. The customer relationship life cycle from initial contact, negotiations, system contracting, operation management to contract termination.

For the modelling of the customer relationship life cycle, the relevant sequence and variety of activities is highly depending on the type of market that will be targeted. In many industrial markets, the customer label covers a variety of relevant actors internally in the customer organisation, ranging from the operational staff, support technicians, middle management to corporate technology management. While the simple cyclical customer relationship model, based on the CAC of Vandermerwe [1993], may sufficiently (although stereotypical) describe the sequence of activities of single actor relationship types, PSS offers targeting multiple customer actors must be modelled separately for every identified actor group.

10 A PSS synthesis approach

In the previous chapter, three types of models have been presented as being necessary for the analysis of existing business processes. The combination of actor network models, describing the exchanges between actors involved in a servicing relationship, process models describing the relevant life cycle activities in a standardised form and product life models, connecting the single activities to complete life cycles allow the visualisation of business relationships. In order to convert the insights created from the modelling of concrete business into improved processes and product offers, the synthesis of PSS concepts is necessary. This chapter describes how the alternating consideration of different aspects of a hypothetical PSS can contribute to the creation of robust development concepts and thereby attempts answering the second research question of this research.

A meta-analysis of the development related processes in two case studies

In the research projects documented by the Novenco and Acta case studies, the project approach was the analysis of the existing products and business processes leading to the identification of possible future developments towards service oriented business for the two case study companies. While the research work was based on the collaborative gathering and visualisation of insights between the researcher and the contributing respondents in the companies, the researcher analysed the project process in order to identify patterns that were related to the synthesis of new solution concepts. Besides the analysis of the participative development process in the two case studies, the solution concepts that were created in the interaction were analysed to identify the properties of the solution concepts.

Analysis and visualisation of existing business as base for synthesis work

In both cases, the main efforts in the first phases of the collaboration were put into the creation of models describing the current product life and the related activities of involved actors, based on the modelling approaches proposed in chapter 3 and converted through the efforts of the researcher.

After the initial analysis approach, the following meetings shifted in character to more open discussions, where the implications of the current business conduct were challenged and possible alternative options were created and confronted with the insights visualised through the analysis results. This process of concept creation and confrontation with existing knowledge matches the general framework of the C-K theory of Hatchuel and Weil [2009].

Confrontation of concept with knowledge in three domains

While shifting between creation and evaluation of concept ideas, the elements of the resulting PSS concept grow. The concept description is composed of elements from three distinct but interlinked domains, resembling the equivalent gradual concretisation and detailing of solution concepts in engineering design as described by Andreassen [Andreassen 1980] in the so-called domain theory. The three domains constitute the framework for the creation of the PSS concept model, each contributing to the definition of the whole from different angles of view.

In conclusion, the creation of service oriented business concepts can be based on the completion of three interrelated description domains, as illus-

trated in Figure 71, being the consideration and concept creation of actor networks, activity systems and artefact systems.

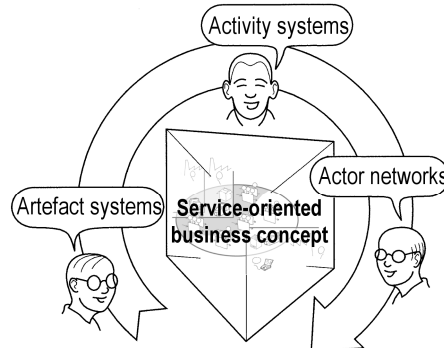


Figure 71: The three domains describing PSS.
Adapted from [Hansen and Andreassen 2002].

Iterative shifting between domains and detailing of elements leads to concept creation

In the synthesis activity, the concept creation is happening through the implicit shifting and refinement of the solution concept in the three domains described above. The resulting PSS concept will take the form of modelling elements from all three domains. The PSS concept is creating the frame for the concrete development of the resulting PSS business model, including specifications for physical products, institutional relationship models between involved actors and definition of service processes and the necessary resources in terms of competence and capacity.

10.1 The artefact system domain

As discussed in section 2.12, Araujo and Spring [2006] and Callon et al. [2002] describe the importance of stabilising offers (no matter of what character) into a standardised state, before offering them for exchange on the market. In the synthesis of PSS concepts, this holds true also, as their content and value proposition must be stabilised into comparable and comprehensible elements in the developers mind. The concretisation of the PSS into such comprehensible separate elements is one of the domains of PSS synthesis, i.e. an artefact system domain. The artefact system domain is conceptually close to the concept of socio-technical systems (*Sozio-technische Systeme*) as defined by Ropohl [1999].

In the artefact domain view, activity processes are stabilised into delivery elements, thereby making the sequence of use activities comprehensible for the developer. On the detailed level, the resources employed in the use or delivery processes can be described. Requirements to hard- and software products can be specified. The necessary competence and capacity of the service delivery system can be identified. The PSS concept is comprised of delivery elements codified into products, service offers and contractual agreements.

Offer portfolio definition

In the artefact system domain, the PSS can be represented as a portfolio of offers, which is the combined programme of defined product and service propositions, and it represents the company's own expression of its deliverable capabilities and competence towards its customers. An example is the high level offer portfolio vision of Danfoss Food Retail in Figure 57. It

lays out the envisioned portfolio of offers for a specific technology or product area (in this case refrigeration systems) and a defined application area (food retail stores).

Institutional arrangements (e.g. financing plans or technical insurance) and service offers (i.e. offers regarding operation supporting activities between provider and customer) are regarded equal to product offers (e.g. components) in terms of being an opportunity of delivering utility towards customers. The offer portfolio represents the variety of identified competences (mainly services), deliverable functionalities (mainly through products) and the institutional arrangements (mainly liability related), which the company can turn into business and business relations with their customers.

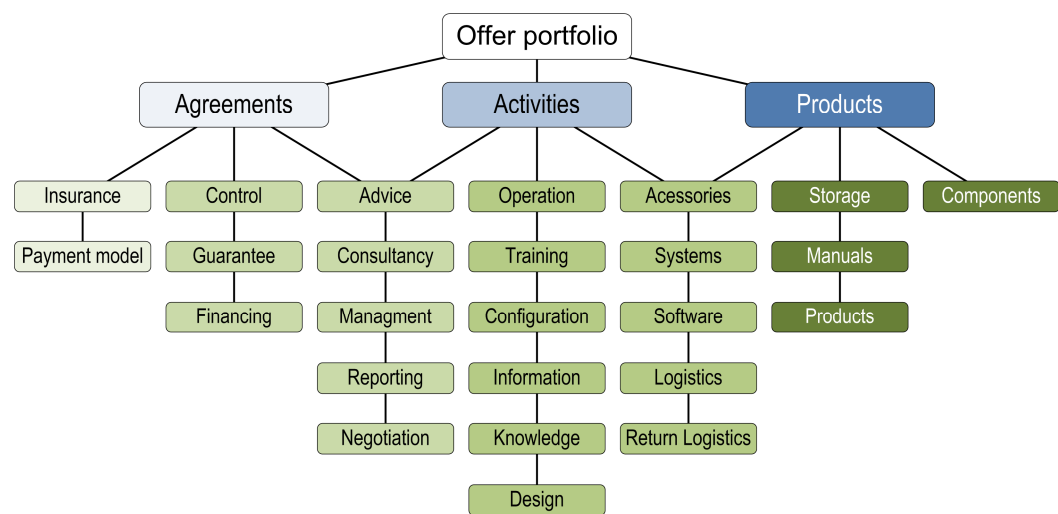


Figure 72: A generic PSS offer portfolio of competences and deliverables.

Figure 72 illustrates a generic categorisation of the PSS offer portfolio and the resulting variety of value propositions to customers, based on the variety of concept elements encountered in the case studies. It represents a *snap shot* product view of the PSS provider's current capabilities and product portfolio.

On a more detailed level, the emerging offer portfolio can be broken down into specifications of the resources necessary for their delivery. Through the iterative synthesis process of detailing and concretising while alternating between the three domains, the initial offer portfolio is gradually detailed.

10.2 The activity system domain

In the activity system domain, the solution concept element is represented as an activity that is executed within a chronological sequence of related activities. The activity system domain view corresponds with the service modelling literature reviewed in chapter 2, which stresses the importance of defining process steps and sequences in service interactions. In the case studies, it became clear that the activities within a PSS must be modelled both individually to explore critical steps in the single process and on a life phase and product life level, in order to identify the dispositional links between activities.

As an example, the activity of conducting a closer supervision of system installation work (delivered by shipyard employees) in the case of Novenco FF would impact later inspection and maintenance activities of the company positively, as proper installation and correct documentation of the system setup eases maintenance processes significantly.

In the activity system domain, the main step from analysis models to concept creation is taken. The reason for this is that the activity system view is the main view applied in the modelling of product life and use processes using the PTrS (cp. chapter 3). Initiating these $K \rightarrow C$ steps are the open options of exchanging operators in existing processes, or investigating the effects of altering identified process steps. E.g. the transfer of responsibility from one actor (or operator) to the other in a modelled process triggers changes in both the artefact domain (e.g. usage is exchanged with being serviced) and the actor network domain (e.g. operational responsibility is exchanged with quality demands and dependence on the service partner). The alteration of one parameter thus can initiate the rearrangement and rethinking of resource and relationship aspects, leading to the creation of a new system configuration.

10.3 The actor network domain

The third domain of description necessary for the creation of a PSS concept is the domain describing the relations between the institutional actors active in the PSS, i.e. the actor network domain. For every process in the activity system domain, a distinct actor network is mobilised, although many single networks will be virtually identical and some might be persistent in spanning several or all activities in the PSS.

While the activity system domain is describing the delivery processes in the PSS, the actor network mirrors the relationships and exchange flows between the actors mobilised in the execution of the processes.

In the conceptualisation and development of PSS in the case studies, graphical modelling schemes have been found suitable for the modelling of actor networks, such as the *customer chain model* (CC) of Donaldson et al. [2006] a variant of which was used for modelling in the case studies. Also the *activity modelling cycle* (AMC) (cp. section 5.3.4) can be used for the identification of the actors involved in specific use processes along the life cycle sequence of activities. The difference between the two models is the discrimination between different networks mobilised in specific activities using the AMC/CAC model, while the CC model does not separate the networks of separate activities.

In the actor network domain, it is possible to assign responsibilities, indicate contractual restrictions and the flow of money, utility and materials. In this domain, the processes of the activity system domain are only visible through the exchange that is created by them between the actors and the chronological sequence of exchanges is substituted by a view spanning the broader scope of the whole PSS relationship.

The revenue mechanism and the institutional arrangements between actors were identified as important factors in the creation of PSS concepts, as they define the incitement structure guiding the involved actors' behaviour as partners in the PSS. The agreement setup is principally unique for every PSS company and might even differ between customers, but in general the

Agreement aspects as object of PSS synthesis

issues shown in the morphological matrix of Table 8 are clarified by the conditions or contracts between provider and customer. The matrix is not all inclusive, but represents the main variables of concern that were encountered in the case studies. Not all combinations between variable variations are feasible or sensible, although a large number of combinations are indeed possible. Unlike the morphological matrix known from engineering design, some alternatives can be combined as shown in the example in the table.

Table 8: Morphology matrix representing important control variables in the provider customer relationship, based on [Tan and McAloone 2006].

Relationship controlling variables	Offer elements in contract	Property right division	Payment model	Operational responsibility	Maintenance responsibility	Liability for operational state	Derived liability
1	Standard product	Transfer at time of sale	Once at point of sale	Customer	Customer	Customer	Customer
2	Customised System	Transfer after commissioning	Financed	Customer trained by provider	Customer guided by provider	Shared	Restricted customer
3	System and service unit	Transfer after defined period	per use	Customer supported by provider	Customer managed by provider	Provider	Restricted provider
...	System and service support	Transfer for defined period	per time unit	Provider	Provider on demand of customer	...	Provider
...	Services	Use rights only	per non use	Licensee of provider	Provider	...	...
...	...	...	Performance related	...	Licensee of provider	...	...
<i>n</i>	...	...	...	...	...	...	...
Example of configuration	System and service support	Transfer after commissioning	Financed + per time unit	Customer supported by provider	Provider	Provider	Customer

Many researchers have focused on these relationship controlling variables as central constituting parameters for PSS in their research, and have effectively built their central models for categorising PSS on a selection of their possible variations. An example is the 8 category PSS typology of Tukker [2004] as illustrated in Figure 5, which essentially represents 8 of the commonly found combinatory configurations of the 6 relationship control variables in Table 8.

Market practices restricting the introduction of novel agreement constellations

The case studies revealed that an important aspect restricting the introduction of flexible or novel agreement structures were the existing practices in the current market. For the customer companies, the comparability of offers from different suppliers is important in their projecting processes, as a non standard value proposition (cp. [Callon et al. 2002]) will introduce new unevaluated elements of risk in their evaluation. Therefore it is difficult for a supplier such as Novenco to introduce novel contract configurations on a general basis. With selected key customers however, the exploration of changed institutional responsibilities is easier, as the Danfoss case documents. In these cases the customer is selected according to his willingness of aligning his processes to the capabilities of the supplier, and for key customers, the investments in building the necessary broader contact network can be justified.

Options of combining technical excellence with liability options

For health or safety related service offers, such as food quality management in the case of Danfoss or SOLAS [IMO 2004] related safety inspection services in the cases of Novenco and Acta, the contractual placement of

liabilities is of paramount importance. In the three cases of this thesis, the PSS providers have all refrained from taking over liabilities regarding their customers' operational risk. From the viewpoint of customers on the other hand, the combination of management or operation services regarding technical assets and e.g. supplier mediated reduced insurance rates based on the operational excellence of the service supplier could represent a unique value proposition.

Options of combining technology and financing solutions

In other cases the inclusion of financing services with a product offer is an important factor for e.g. leasing companies, indicating the integration of utility, financial and liability considerations of customers, consumer and businesses alike. The much cited case of Xerox Corporation's choice of a lease based revenue mechanism to support the electrophotography copying technology, documents the close coupling between the technology and economic elements of successful PSS [Chesbrough and Rosenbloom 2002].

Necessity of employing different models in parallel

As the Danfoss case study documents, the PSS providing company will almost always be in a situation that enables and requires the concurrent marketing of a broad variety of PSS configurations, regarding both the combination of offer elements as the configuration of the sales model. This is especially the case for companies with a legacy of a traditional product oriented business model, as existing customer segments not readily will change their existing business patterns.

10.4 Conclusions regarding the synthesis process

This chapter presents first insights regarding the synthesis process when utilising the service oriented product development approach. As these insights are based primarily on the analysis of processes influenced by the researchers interaction in a participative research context, the results must be regarded as preliminary and need to be validated in further studies.

The synthesis of new concepts in a service oriented product development context is proposed to be closely coupled to the analysis of existing business processes and initiated by the conceptual alteration of elements. The synthesis process should be an iterative shifting between the mental detailing and concretising of solution models in three domains. The three domains constitute different representations of the same elements and interactions, each contributing to the creation of knowledge based on a conceptual exploration of variation opportunities.

11 Staging service oriented product development

In the previous two chapters, an approach allowing the analysis of current- and synthesis of future PSS solutions of the company have been explored and described. In this last contribution chapter, the embedding of these models for service oriented product development into the development function of the manufacturing company is treated and the third research question is answered. The three case study companies are drawn in to allow the identification of challenges and opportunities.

The three case study companies described in the previous chapters were all coming from a tradition of manufacturing of physical products and experiencing a raising focus on after sales and service activities in their field.

For Danfoss, the increasing communication and remote control capabilities of their products opened the opportunity of monitoring and supporting customers' operations. The company was facing strong competition regarding the core functionality of their products, and the ever increasing integration of control functionality between components in single systems and between system functionality and service offers on the enterprise level was evaluated as one of the future competitive advantages of the company.

For Acta, the implementation of legal safety regulation forced the company to build an efficient and global inspection service delivery system. This initiation of proactive service offers slowly sparked a strategic shift towards service delivery. In the light of the future prospects for European ship-building activities this shift could prove a main source of revenue for the small engineering and manufacturing company.

For Novenco the after sales department managers anticipated the growth of after sales activities due to the ever increasing work and competence division between actors in the maritime market, and sought for a structured approach to the development of their capabilities. Like Acta, the future prospects of Novenco's business seemed to be in the integration of product and service offers, demanding a professional development of this area.

The previous two chapters propose that the synthesis of concepts in service oriented product development is based on an iterative process of analysing the existing product life and business processes and conceptualising alterations and changes in these patterns in order to optimise the overall solution performance. The development domains include the definition of new or altered concepts for product technology, delivery processes, delivery networks and even the fundamental constitution of business and revenue models, thus spanning a very broad range of functional areas of the company.

This wide span of concept elements each have their own contextual linkages in the company structure, and equally have their own development dynamics.

11.1 Development dynamics and -levels

As described in the Danfoss case, every customer relationship develops through a sequence of phases and activities, which are mirrored by the activities of the provider's delivery system units. For the RETAIL-CARE™ customer team, e.g. negotiations are replaced by contracting projects, which again are succeeded by site surveys and followed by reporting services. The resulting experience and knowledge gathered by the provider's customer team can be utilised for improving the specific customer relationship as well as developing the general value proposition and delivery system of the provider.

The example above illustrates the ad-hoc development of service systems, based on concrete and expressed customer demands (cp. [Foote et al. 2001]). This approach, contrasting the synthesis based approach of service oriented product development presented in the previous two chapters, is an important element in the dynamic development of offers in the context of PSS. It leads to the identification of several development levels, partly driven top down, partly bottom up. A representation of these development levels is offered in Figure 73. There is no clear division between developments solved by either the standardisation or the product development approach, but generally longer term developments seem to be supported by the service oriented product development approach, while more dynamic and local adaptations are initiated by bottom up approaches.

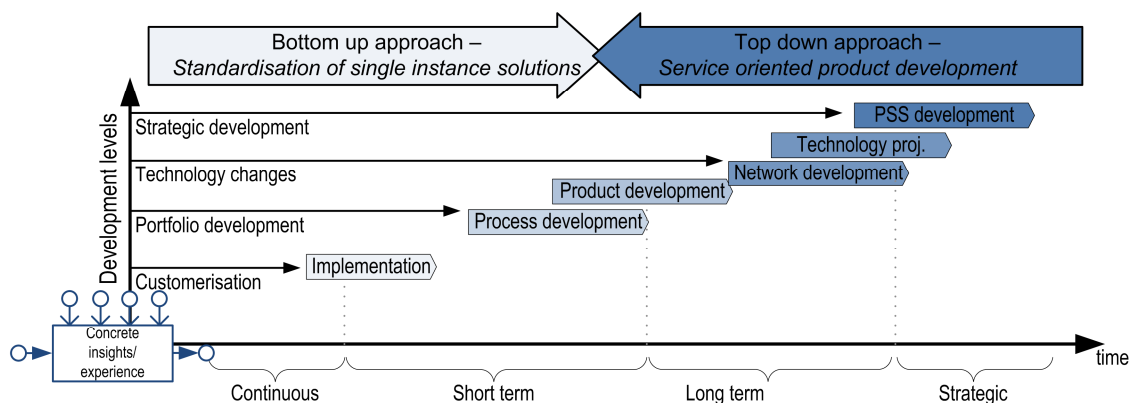


Figure 73: Development levels in PSS, ranging from continuous adaptation of services to the strategic development of PSS.

Customerisation

The delivery system units (customer teams, technicians, web-interface managers) in effect constitute the customers interface to the delivery systems of the company and adapt the capabilities of the company to the current needs of the single customer. The individualisation of deliveries towards the single customer, being proposed as one of the advantages of PSS models (e.g. [Manzini et al. 2004]), depends on the flexibility and empowerment of these systems and employees. On this level, the PSS configuration and adaption can happen on a day to day and interaction to interaction basis, allowing a highly dynamic matching of offers to the customer's needs.

The downside of this direct matching of needs with service deliveries is that the implementation is restricted to the single system instance (or cus-

Portfolio development

tomers) and depends on the competence, empowerment and flexibility of the involved employees and their support systems.

It is therefore important to implement systems for the retrieval and evaluation of single instance solutions, in order to enable the gradual development of new or improved offers across all system instances.

In the Acta case, the safety inspection services led to customers asking for general technical surveys of selected equipment. These individual arrangements could have been converted into a general service offer, diversifying the portfolio of the company towards ship owners.

The standardisation of valuable deliveries from one instantiation to the general portfolio allows the frequent introduction of new elements to the PSS, if the additions can be delivered in sufficient quality and at competitive cost.

The bottom up introduction of new service offers render service systems more dynamic in their adaption to the changing needs of customers, compared to the development and marketing or exchange of product elements. Software systems are typically also more flexible in comparison to hardware products, given they are build on an open and configurable architecture.

An example of dynamic and gradual offer development in the software market is the continuous introduction of new features in web based services like e.g. the email service Gmail.com, where new functionality is offered as software modules but the provider typically refrains from taking responsibility for the full stability and functionality of the solutions (which remain in a so-called beta-version to indicate that the user in effect is part of a usability experiment).

Technology changes

The short term and direct development of service offers on a bottom up basis must be supported by a structured and long term oriented development of products, service delivery systems and the general business model governing the company's activities.

This development level is labelled technology changes, as it represents development of products and delivery systems that require considerable changes of architecture, functionality or technology. The traditional product development tasks of introducing new product generations and adding new functionalities to existing product families is good example of development projects having the properties of technology change.

The division between portfolio development and technology development levels is obviously not clear cut and depends on the particular context. An important factor that must be considered in structured development projects is definitely the creation of an open architecture of products as well as service and delivery support systems, allowing the later adaptation of solution instances and the offer portfolio. The integrated development of open architectures that considers the dispositional links between products and service system setup is where service oriented product development concretely influences the specification of traditional product or service development projects.

In the Novenco case in section 0 the example of the nozzle design underlines the importance of the physical product designs alignment with the setup of the service system supporting it. In the case study, the nozzle de-

sign in effect prohibited the creation of a flexible service system, as the exchange of nozzles was too time consuming and required the clearing of complete FF sections of passengers in order to execute servicing operations.

On the fourth development level, the conceptual and strategic configuration of products, services, delivery networks and the institutional relationship to customers can be challenged and defined. On this development level it is possible to re-evaluate the current configuration of the company's business model, and options arising from radical changes in one of the parameters of the PSS. Issues such as the employed revenue mechanisms, the division of operational responsibility between customers and the service system etc. can be discussed and changed, given that the development team is given the competence of taking decisions affecting the business across several functional areas and hierarchical levels.

11.2 Positioning within the company development function

As noted in the previous paragraph, the radical change of central business parameters is both difficult, risky and requires the participation of senior decision makers in the process. In the concrete context of the manufacturing company, this is a rare situation, and in effect this means that many decision variables will remain fixed specifications throughout the conduction of the development efforts. The Danfoss case study, in which the positioning of the service oriented product development approach in the development function of the company was investigated, underlines this clearly.

Within the particular company context of the Danfoss refrigeration division, it seems natural to position the creation of PSS concepts in parallel to existing project portfolio development processes. In comparison to these front end development projects, the service oriented product development process has the following similar properties:

- The results of the synthesis processes are presumed detailed to specification level – similarly to the project descriptions being part of a product development portfolio plan.
- The process requires inputs from a broad range of internal and external specialists in order to allow the creation of a detailed model of the as-is situation, and possibilities or critically assessing emerging concept proposals.
- The service oriented product development synthesis process- and result dimensions cover a broad range of company functions, i.e. the elements of resulting concepts represent a variety of separate development tasks, requiring a diverse set of capabilities. Although this is not the case in the existing front-end processes, these are also executed separate from the subsequent development processes and are sometimes executed in collaboration between several functional departments.

As further result from the Danfoss case, one of the main challenges in implementing service oriented product development is the identification of receivers of the generated concept descriptions. If the selection of concept elements and proposals is done by the existing product development de-

partment employees, their professional competence and focus will inevitably filter concepts not fitting the existing competences in the receiving development department.

In all the three case companies, there were no dedicated development departments other than those dedicated to hardware- and to some extent software products. RETAIL-CARE™ had outsourced their software development to sub suppliers collaborating with the hard- and firmware development department (DE). There was no long term service development department defined in the organisation, indicating that service development tasks were solved through implicit standardisation of work practice. In the Novenco service department, the situation was similar, with the development responsibility lying primarily with the department manager.

In the Novenco and Acta cases, the process of product life analysis, followed by iterative synthesis loops was welcomed as a possible approach to service development in itself. While this might be productive for the execution of service development projects in manufacturing firms, the insights from the Danfoss case seem to underline that to achieve balanced results creating integration and synergy between products and service support, an unbiased facilitation of the development approach is necessary.

Generalising the insights from the cases, the following positioning of service oriented product development is proposed:

- The development process must be facilitated separately from the existing functional departments of e.g. product development, manufacturing, projecting, sales, after sales, financing etc. The reason for this is to achieve balanced concept results as described above.
- The conduction of a service oriented product development project should be guided by a general goal specification, although a too rigid specification, in similarity to other innovation approaches, reduces the obtainable innovation height.
- The process must be manned by a combination of competences from the different relevant functional departments, if possible including customer and network partner representatives. This will ensure the best possible analysis basis, and improves the robustness of concepts created in the synthesis process.
- The goal of a service oriented product development project should be the specification of development tasks, which subsequently will be executed by the separate functional departments or partners, utilising their superior domain knowledge.
- The development and implementation of concepts must be supported through collaboration across functional barriers, in order to allow identified synergy effects to be realised.

The staging of service oriented product development is illustrated in Figure 74.

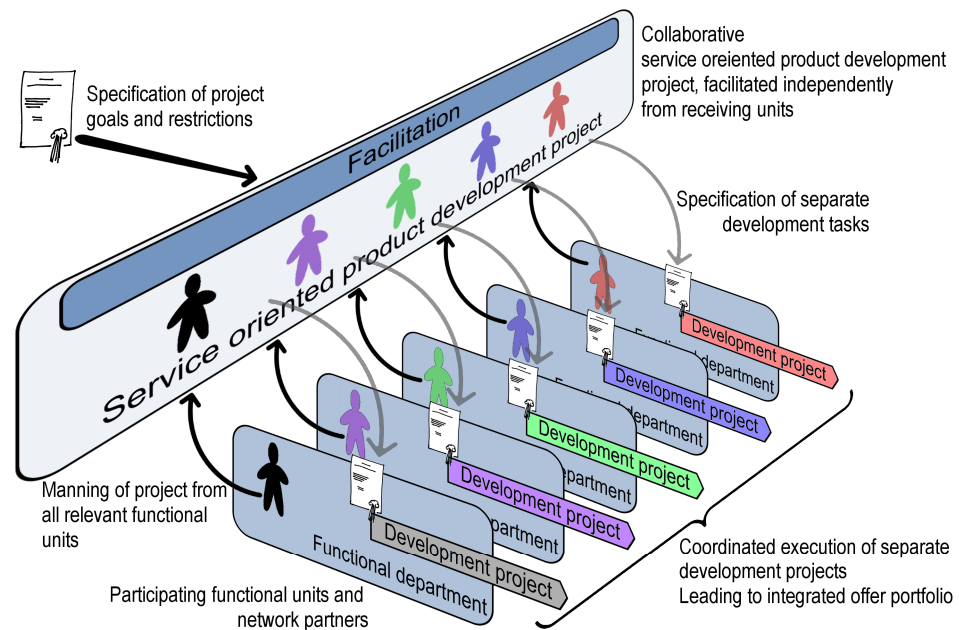


Figure 74: Proposed staging of service oriented product development.

11.3 Conclusions regarding the staging of development

The implementation of development approaches in real organisations is obviously highly dependent on the specific company context and the existing structures and processes. However, PSS business models have specific properties regarding their dynamic development and adaption to customers, which results in the necessity of a double approach to the development of the PSS. One approach is the bottom up approach of reacting to customers explicit demands and adapting the system configuration accordingly. This approach has been investigated by other researchers and seems well suited for short term and minor developments of the PSS. The other approach, which is characterised by a longer lead time but higher innovative steps is the service oriented product development approach that is the theme of this contribution. The two approaches can complement each other if the system architecture is open and flexible.

The product development approach is affecting a broad variety of company functions and thus must be positioned in a cross functional development structure in the company. This de facto moves service oriented product development close to the company processes of project portfolio management and – depending on the decision competence present in the process – strategic development of the company.

12 Discussion and conclusions

In the preceding chapters, the insights gathered from literature and the experiences from the presented case studies and other projects with Danish industrial firms have been analysed and turned into a number of models. These will now be scrutinised and discussed in order to point to their research implications and practical applicability.

Based on the discussion the core contributions of the research project are summarised. Finally suggestions for future research in support of service oriented product development are given.

12.1 Discussion of findings

The three preceding chapters each attempt the answering of one of the stated research questions. In the following sections, the findings are shortly summarised and their contributions and implications are discussed.

12.1.1 Identifying key activities and relationships through process modelling

In chapter 3, the parallel transformation system model (PTrS) was presented (cp. Figure 39). It was initially derived from literature and thought experiments based on the presumption that all activities related to the product can be modelled as processes. Every process can in principle be shared between different actors and the reassignment of process responsibility between actors or between actors and other operators can yield productive inputs to the improvement of the process performance.

Chapter 3 also described how it is necessary to consider the activities of two lifecycle periods, namely the lifecycle of the product and the lifecycle of the provider's relationship with the individual customer (cp. Figure 41).

Throughout the three case studies the modelling framework of the PTrS has been used to analyse the current business processes of the three case companies, and furthermore to predict possible alterations of the delivery processes modelled.

In the cases the process modelling was guided by preliminary analyses of the product life cycles, through which influential life phases and critical activities within those life phases were identified. In the Novenco and Acta cases, the modelling of life cycle activities was mainly oriented towards the product and the crew's interaction with the product, thereby supporting the initial assumption that these two lifecycles were of main interest for the modelling of a products service life.

In the Danfoss case, it was found that the main sequence of activities important for successful service delivery of RETAIL-CARE™ was not the sequence of activities throughout the product life, but the evolving life cycle of the customer enterprise and the management processes of acquisition, integration and growth of the food retail business area, including the development of management and accounting practices.

Based on the insights from the three cases, the preliminary assumption of the necessity of following two life cycles was altered to the resulting model of service oriented business processes presented in chapter 3.

Contribution	Based on the research presented in this thesis, a systematic modelling approach for the modelling of value creating processes in the relationship between a product/service provider and his customer has been defined. The process model, used within the framework of a life phase analysis of primarily the product, secondly the user organisation, thirdly the governing customer management and finally other influential actors can identify, spell out and illustrate the delivery elements towards the customer and important links between different functional activities of the provider company.
Limitation	<p>In resemblance with the original TrS model, on which the PTrS model is based, the process model can only describe transformations (activities) and the resources necessary for their execution. The model does not show how or why the modelled activities create utility or value for the involved actors. Thus the modelling results must be evaluated in terms of which involved actors will benefit in what ways from the modelled process.</p> <p>Furthermore, the sequencing and linking of single processes is the responsibility of the person using the modelling scheme. Thus the productive results of the modelling efforts are still highly dependent on the insight and experience of the developer.</p> <p>Finally, the systematic modelling approach in itself requires the creation of a standardised sequence of activities (defining a prototype life cycle model) and a standardisation of the process execution itself (defining the process content of the single PTrS model). This standardisation necessitates the explicit consideration of alternative process sequences and processes, in order to render the resulting model to be robust concerning different product life alternatives.</p>
Research implications	The application of the PTrS model allows the systematic modelling of socio-technical use processes. Within the framework of life phase models, the model can help to identify how use processes are sequenced and linked, and how different actors effectively collaborate on the creation of practice regarding technology use. The life phase models themselves can be utilised to follow and explore the activity trajectories of involved actors in a uniform and comparable way.
Practical implications	The identification of dispositional links between different company activities and functional areas enables the development of new or altered delivery processes, product conceptualisations and, given the necessary organisational empowerment of the involved actors, business models.

We can use the service life models to convince the product development department to include serviceability issues in product development. Until now we have had no way of supporting our case. The development people always see their designs in the tidy and spacious assembly hall, never in their real life environment.

Service developer at Novenco

The quote above underlines the importance of creating a language, which allows the different functional areas and departments of the company to exchange experiences and ideas. The systematic process modelling may ease the discussions between different professions in the company, thereby improving the creation of better overall solutions.

12.1.2 Concept synthesis based on three alternating viewpoints

Contribution

In the quest of identifying new opportunities and creating business from their exploration, the analysis of current business processes must be followed by the synthesis of solution concepts for future products and solutions. Based on the analysis life phases and activities a set of productive cognitive domains for the synthesis of PSS solutions have been identified.

In resemblance of the domain theory of Andreasen [1980], this research proposes the synthesis of PSS to be based on an iterative process, where the forming solution concept is detailed and concretised in a continuous shifting of view between three interlinked domains. These domains are called the artefact system, the activity system and the actor network domains respectively.

In the activity system domain, the main modelling object is the utilisation process, which is one of the aspects described by the PTrS model.

In the artefact system domain, the main modelling objects are the resources necessary for the execution of the planned processes. These are represented by the operators being the other main aspect of description of the PTrS model.

In the actor network domain, the main modelling object is the creation and exchange of utility, information and value between the actors involved in the PSS. These exchanges can best be illustrated by the creation of visual actor network models.

Limitation

The synthesis approach described in this research covers only the creation of general concepts regarding a future PSS solution. It allows the identification of necessary products, competences and resources, and it helps define the actual delivery processes of the PSS. Requirements can be set and performance parameters decided. The detailed development of the single elements of the future solution concept are not supported by the approach, and it is assumed that existing approaches, such as e.g. mechatronic product development for the case of technical products, can be utilised in the further concretisation of the single solution elements.

In this contribution no specific and comprehensive models for the complete description of PSS concepts could be defined, leaving the research question 2.b on page 68 partly unanswered.

Research implications

The research has shown that existing synthesis approaches identified within the field of mechanical engineering design can be reapplied and yield productive results in the synthesis of value propositions for PSS.

Practical implications

For the practical development of PSS solutions, the prospective development team needs to consider the concept under development from three alternating viewpoints, being an artefact, an activity and an actor network view.

12.1.3 Staging service oriented product development

The synthesis of solution concepts must always be embedded in the context of the provider company, as the implementation and realisation of synthesised solution concepts is only possible if commitment and support can be found in the company. Furthermore, the synthesis of realistic solutions is only possible if the current and future competences and capacity of the provider is taken into account. Many research contributions in the past

Contribution	<p>have presented methodologies for the development of PSS solutions, but these methodologies have often not been related to the functional structures and responsibility hierarchies of the industrial company.</p> <p>Service oriented product development is positioned in the development function of the company as a development approach that spans across the traditionally separate functional areas of the company. It allows the creation of integrated business concepts, which subsequently can be detailed and concretised through the parallel efforts of different functionally separate parts of the organisation.</p> <p>Service oriented product development explicitly supports the exploration of changes in the balance between product functionality, service offers and effects of different business models.</p>
Limitation	<p>The contribution in this thesis covers only the identification of service oriented product development as being an activity that mobilises collaboration across both the hierarchical and functional levels of the company. The concrete realisation of these requirements of broad involvement in development efforts has only been considered for single cases, which does not define a generally applicable rule or method. In addition, not all service oriented product development needs to or should be allowed to reiterate all decisions defining the company's business model. Also the inherent dynamics of radical, as opposed to incremental innovation, are not challenged in this research contribution.</p>
Research implications	<p>For the research community, the contribution regarding the positioning of service oriented product development opens the question of how systematic development of service systems fits into the existing field of research within development management and portfolio management. There is no clear cut distinction between these fields, and the inclusion of more and more parameters into the development task in service oriented product development underlines the necessity of reassessing the division of responsibilities between product development, development management and general business management.</p>
Practical implications	<p>For the company being in the transitional phase between product and product/service orientation, the examples described in the cases of this thesis, together with the results of the analysis can give inspiration regarding new ways of dividing and managing the different development tasks in the company.</p>

This is the next step, allowing the engineering designer to consider service issues in product development – in the same way they are now using DfX methods, e.g. Design for Manufacturing.

Quality Manager at Novenco FF

Whether service oriented product development is utilised as a more thorough approach to improving the use phase performance of products, as the quotation above implies, or if service oriented product development should be used in a more strategic development and repositioning of the company (as implied below) is obviously the choice of the company.

We can use these models and methods to create the vision and define the elements of future business models.

Service Manager at Acta

12.2 Contribution to the Copenhagen school

This research contribution is adding to the *Copenhagen school* [Andreasen and McAloone 2008] that was referred to in the very beginning of this thesis in a number of ways:

Firstly, it explores how the task of product development has evolved since the presentation of *integrated product development* [Andreasen and Hein 1987] in the 1980'ies. In that paradigm, the task of product development was focused on the efficient creation of (physical) products and matching manufacturing systems, based on thorough understanding of the market situation and potentials. In the current and future business situation, the product construct is expanded to include service life support of products, in effect turing the delivery systems of the provider and his network partners into a part of the offered product. As a consequence, the distinctions between product development, process development and business development are becoming blurred. Service oriented product development offers a systematic design approach that may support the creation of a platform for the company's broader product development task.

Secondly, the theory of dispositions [Olesen 1992] has been applied and consolidated for the life phases of use, maintenance and termination of products. The theory of dispositions was initially proposed based on the exploration of dispositional links between the product and the life phases governed by the manufacturing company, where this contribution adds further links to business processes such as sales, configuration, projecting etc. The contribution thereby links to the work done in the areas of modularisation and platform development, in which the creation of product platforms for improved configurability [Harlou 2006] or the creation of engineering platforms to allow for efficient projecting of customer solutions [Miller 2001] is attempted.

Finally, the identification and exploration of use processes as the primary source of product functionality, utility and effects is transferred from the initial use in EcoDesign methods [Olesen et al. 1995] to the more general synthesis and development of solution concepts. The research in this way also reaches out to relevant research streams within sociology [Callon et al. 2002], which stress the users influence on the domestication and subsequent effects of technology.

12.3 Core research contributions

Regardless of its positioning in the tradition of the *Copenhagen school* of engineering design and product development research, the contribution advances knowledge within the field of product development. The five core research contributions of this project are:

1. A systematic approach allowing the visualisation of product life and related use activities is defined.
2. Service development must consider a broad range of actors not directly associated with use processes, but rather linked to the product life through associated processes and crossing life cycles.
3. The synthesis of PSS concepts relies on the iterative detailing and concretisation of elements utilising three view domains, being artefact-, activity- and actor based.
4. The development of PSS concepts is a collaborative high level effort, spanning across all or many functional areas of the company.
5. The manufacturing company needs to create an organisation or team in every affected functional area in order to contribute to, receive and implement concepts developed in the collaborative service oriented product development activity.

Especially the last two items emphasise that the task of service oriented product development is not to be confused with engineering design, but rather is to be regarded as a design based approach to the general coordinated development of company business.

12.4 Future research

The contributions of this research are primarily oriented towards the modelling of existing business or hypothetical future PSS concepts, based on a process model. Many issues still remain to be researched into, in order to stabilise the approach of service oriented product development.

Definition of procedural models

The research presented in this thesis assumes an iterative modelling approach based on the continuous evaluation of current insights and necessary detail. To make the current approach operational, the definition of procedural models for the conduction of the service oriented product development approach is necessary.

Selection and filtering of life phases and activities

In the research context of this project, the selection of focal activities and life phases for the modelling of processes has been primarily been decided by the researcher, based on opportunities and the insights available. In a future research, it could be investigated how the filtering and selection of modelled processes and life phases can be made more robust and stable.

Concept documentation models

Although this research has identified the three domains most important for the concretisation and evaluation of PSS concepts, there has not been identified a concretely applicable set or system of models for the complete description and documentation of PSS concepts. Thus the approach of service oriented product development is currently still open ended in terms of the results that can be expected.

Organisational anchoring in the company

This research proposes that service oriented product development should be positioned as a high level collaborative development activity in the company. Still it remains undefined who should be responsible for the initiation and conduction of the development activities.

Ensuring development and
implementation of partial concepts

Acknowledging the necessity of applying detailed professional knowledge in the concretisation and implementation of created concepts, it is unclear how to organise the development of the partial concepts originating from a service oriented product development activity. In the manufacturing companies that were visited during this research, only few had dedicated development organisations besides the traditional (physical) product development departments.

Linking with development
management

Finally service oriented product development is an activity that reaches towards other high level development management activities in the company. The links and positioning of service oriented product development in relation to other high level decision structures in the company is not defined from the existing research.

12.5 Concluding remarks

The application of product life models in the industrial context of manufacturing firms has proven that the approach is highly productive, in identifying opportunities and possible business cases, regarding the integration of product features and service offers. Nonetheless, the concretisation of these concepts and the harvesting of the identified synergy effects is a non trivial task for the manufacturing company, due to internal as well as external challenges. To overcome these challenges must be the highest aim of future research.

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